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SMALL SAWMILL UTILIZATION OF APPALACHIAN HARDWOODS

Part II -- TIES, TIMBERS, AND LUMBER

Production Costs, Tie, Timber, and Lumber Grades, Mill and Woods Practice in Relation to Forest Management and Profitable Lumbering on the Shenandoah National Forest, Virginia and West Virginia.

By R. D. Garver, Senior Forester
and
J. B. CUNO, Associate Wood Technologist
with the assistance of
National Forest Region No. 7
and the
Appalachian Forest Experiment Station
Forest Service, U. S. Department of Agriculture

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By

R. D. GARVER,[1] Senior Forester
and
J. B. CUNO, Associate Wood Technologist
Forest Products Laboratory[2]
With the Assistance of
National Forest Region No. 7 and the
Appalachian Forest Experiment Station
Forest Service, U. S. Department of Agriculture

SYNOPSIS

This report contains the facts and figures resulting from an intens ve logging and milling study carried on by the Forest Service among mall sawmill operations cutting Appalachian hardwoods into ties, timbers, and lumber on the Shenandoah National Forest in Virginia and West Virginia. A companion report giving comparable data on small sawmill operations cutting Appalachian hardwoods into lumber on and in the vicinity of the Pisgah National Forest, North Carolina, has been issued as Part I of this report.

The present report gives first a summary of the main points brought out by the study after which is shown detailed information on the methods of study, character of mills, cost of producing and value of ties, timbers, and lumber from trees of different diameters and species, overrun, grades of ties, timbers, and lumber, merchantable volume tables, efficiency of the different mills, material left on cut-over areas, and other points bearing on small mill operations cutting ties in the Appalachian hardwoods.

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[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

SUMMARY OF RESULTS

The following information applies directly to small, circular sawmill operations and to Appalachian hardwoods as found on the Shenandoah National Forest, Virginia and West Virginia:

1. Tie and timber operations provide one of the best means of removing undesirable species, poor specimens of desirable species, and of salvaging poor quality stands of hardwoods in the Appalachians so that another timber crop can be begun with healthy and desirable growing stock. (P. 68.)

2. The average cost of producing ties, timbers, and lumber from five species of the oaks varied from $14.16 per thousand board feet, mill tally, for black oak to $15.64 for chestnut oak. (Tables 18 to 27, inclusive.)

3. The average value of the ties, timbers, and lumber varied from $23.44 per thousand board feet, mill tally, for scarlet oak to $26.31 per thousand board feet for white oak. (P. 12.)

4. The average difference between production cost, not including stumpage, interest, or a margin for profit and risk, and the value of the ties, timbers, and lumber was $8.26 per thousand board feet, mill tally, for chestnut oak, $9.31 for scarlet oak, $9.49 for black oak, $10.34 for red oak, and $10.88 for white oak. (Tables 43 to 47, inclusive.)

5. The overrun, including rejected ties, averaged 36.4 per cent for the five oaks combined. The overrun was extremely high in small logs because they were cut mostly into ties, only a small percentage going into lumber. Furthermore, the small logs, particularly the crooked ones, were often cut into pole ties. (Tables 16 and 17.)

6. Defect, which included crook, rot, and any other defect that reduced the gross volume for the logs brought to the mill, was as follows: Chestnut oak, 16.1 per cent; white oak, 12.8 per cent; red oak, 11.3 per cent; scarlet oak, 11.1 per cent; and black oak 6.9 per cent. (Tables 16 and 17.)

7. The following percentages of ties were rejected by main line railroads, principally because of rot: Chestnut oak, 17 per cent; white oak, 9 per cent; black oak, 20 per cent; red oak, 16 per cent; and scarlet oak, 23 per cent. (Tables 28 to 32, inclusive.)

8. On a net log scale basis, the cost of producing ties, timbers, and lumber from red oak trees 11 inches in diameter was 1.59 times more than that for red oak trees 25 inches in diameter. (Table 13.) When reduced to a mill tally basis the cost was practically the same for the two diameters due to the effect of the extremely high overrun in the small logs. (Table 23.)

9. A larger percentage of the small trees than of the large trees was cut into ties. For example, on the average, 93 per cent of the red oak trees 12 inches in diameter was cut into ties and 7 per cent into lumber, while 73 per cent of the red oak trees 24 inches in diameter was cut into lumber and 27 per cent into ties and timbers. (Table 36.)

10. Good silviculture demands weeding many Appalachian stands. On the national forest timber sale area, where this study was made about 80 per cent of the volume of all trees 12 inches in diameter and larger was cut. One hundred and seven thrifty trees per acre, varying in size from 4 to 21 inches in diameter then remained on the ground. (P. 69.)

11. Eight per cent of the trees cut were unmerchantable. Most of these were chestnut oak, followed by white oak, black oak, scarlet oak, and lastly red oak. (P. 69.)

12. White oak and chestnut oak growing in competition with other species seem to maintain a sustained growth rate better than red oak, scarlet oak, or black oak. (Figs. 8 to 12.)

13. The average yield per acre from tops and limbs left on the cutting area was about 6.15 cords of fairly straight material from 4 to 14 inches in diameter and from 4 to 8 feet in length. (P. 72.)

14. On the average, 31 per cent of the oaks cut were "long-butted" because of rot. (Table 51.)

15. Brush disposal costs on the study area varied from $0.89 per thousand board feet, net log scale, for chestnut oak to $1.28 for black oak. (P. 76.) This variation is due principally to the fact that brush disposal costs more per thousand board feet for small trees than for large ones.

16. Milling costs for small operations cutting ties, timbers, and lumber show less spread between small and large logs than is true in small mill operations cutting only lumber. (Fig. 13.)

17. The output of the mill selected as representing an average in efficiency was 8,940 board feet, mill tally, per 10-hour day. Delay time amounted to 27.6 per cent. (P. 82.)

THE INFLUENCE OF TIE AND TIMBER PRODUCTION ON FORESTRY

The annual increment from about one-fifth the saw timber-growing area of the United States is required to balance the drain on forests for cross ties, switch ties, and bridge timbers. On this basis the tie industry, including both the consuming and producing ends, is custodian of a forest area equal in size to the aggregate acreage of the states of New Jersey, New Hampshire, Maine, Maryland, Rhode Island, plus one-half of Arkansas. It uses about one-ninth as much wood as is consumed as lumber. The importance of the tie industry on forest practice is further emphasized by the fact that sound logs which produce only common lumber are practically as good for ties as logs which produce high-grade lumber. Thus, the tie industry provides a profitable outlet for low-grade material which if sawed into lumber would be difficult to dispose of at a price above its production cost and thereby removes some of the economic obstacles encountered in practicing forestry.

Ties and timbers are holding their markets against substitutes as well as or perhaps better than any other wood product of the forest. Present indications are that they will continue to do so. A tie operation is a two-edged knife, however, so far as forestry is concerned. Tie production can be made to favor good silviculture and close utilization, or, on the other hand, young trees can be slaughtered and the land skinned closer in tie operations than in most any other way. Oftentimes because ties are produced from low quality timber, operators give little heed to utilization. (Figs. 1 and 2.) For example, ties are often hewed, which results in the loss of about 8 board feet of lumber for each tie produced. Or, even if sound, the lumber in the slabs is not always used. It is just as important to practice good silviculture and close utilization on tie operations as on lumber operations. Tie operations are carried on in such a way as to be easily adaptable to selective cutting, either as to the trees to be cut or the areas to be logged. If a company is properly organized it is profitable to utilize the side lumber. Care in tie manufacture has a bearing on utilization and profits just the same as in lumber manufacture. Figure 3 illustrates a small tie operation where carelessness reigned supreme -- lumber and ties were scattered about the site, poor manufacture and utilization, and lack of system were evident on all sides. Profits suffered accordingly. Figure 4 illustrates an operation in direct contrast. Here the ties and lumber were well manufactured, piled, stickered, and put up on good foundations. System and care stood out on every side and profits increased accordingly.

Most of the hardwood timberland in the Appalachians has been cut over to a greater or less degree. Fire has run through the remaining stands from time to time with the result that the trees are for the most part poorly formed and defective. These poor trees should be

Figure 1.--Woods butchery -- on a large tie operation.

Figure 2.--Heavy slabs are found at many tie mills where lumber is given only secondary consideration.

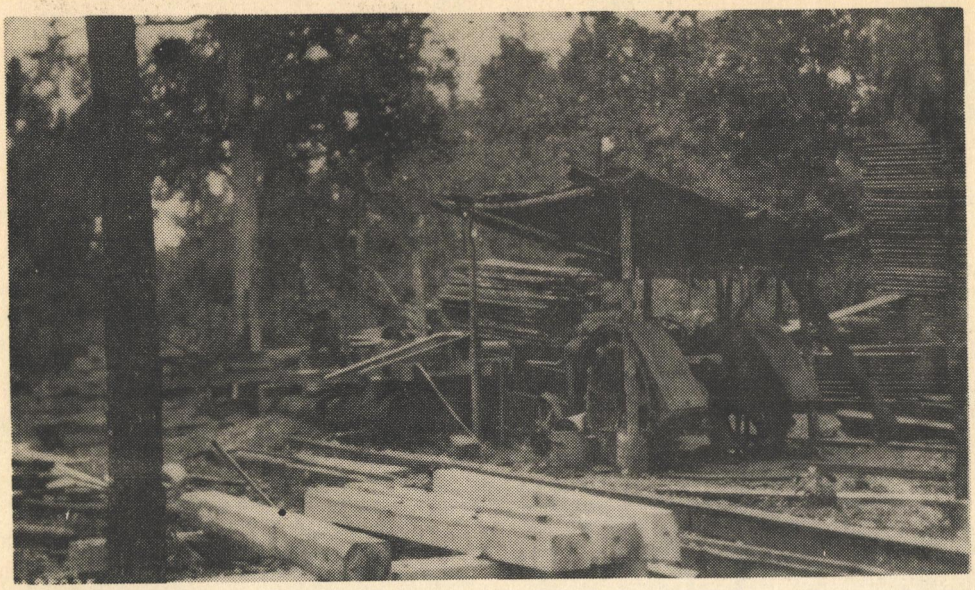

Figure 3.--A mill where carelessness, disorder, poverty reigned supreme.

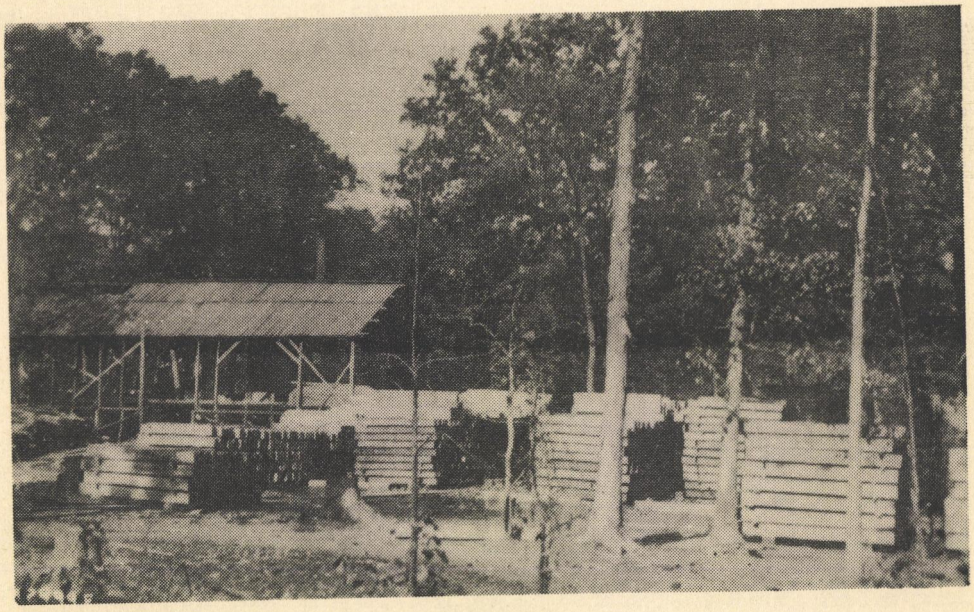

Figure 4.--A mill where care, order, and profits were apparent.

removed from the stands and a portable mill cutting ties and timber seems to be one of the best ways of doing it. If unrestricted cutting is practiced the future production of the stand will be wrecked for a long time. On the other hand, if selective cutting is practiced, enough healthy young trees can ordinarily be left to form the nucleus for a future crop.

The timber on much of the land in the Appalachians is too poor in quality and too small in quantity to warrant large mill operations or to justify private owners in holding it for a future cut. Such stands must be cleared of the inferior growing stock and a new start made if the owners plan to use the land for the profitable growing of timber. With this in mind, the Forest Service in the timber sale on the Shenandoah National Forest in Virginia and West Virginia made provision for leaving some good healthy trees to provide seed and make up the next cut.

On the other hand, many small mills cutting ties in the Appalachians are operating on the "leavings" of large lumber companies with the result that such lands are skinned a little closer. If the timber removed by such operations is of poor quality and will not improve with growth, as is often the case, such a practice is beneficial, for the way is then open for the development of a thrifty vigorous young stand which could not take place under the existing cover. On these areas it is good practice to leave such few groups of thrifty, sound, young trees as occur even though the general practice is clean cutting. If the land is covered with sound, thrifty, young trees in sufficient numbers to provide a future cut, however, clear cutting is decidedly detrimental, for the harvesting of a crop of high quality timber is delayed and the time when the land will again become fully productive extended into the future so far that private capital would not ordinarily be interested in holding it for growing trees.

PURPOSE AND SCOPE OF STUDY

The specific purpose of this investigation was to get information at small sawmills that cut ties and timbers as the principal products on production costs, overrun, percentage of defect, percentage of the different grades of ties, timber, and lumber from trees of different sizes and species, and mill and woods practice in relation to forest management and tie operations in the Appalachian region with particular reference to hardwoods.

This report contains the results of a logging and milling investigation carried on by the Forest Service among the small sawmill operations on the Shenandoah National Forest located in Virginia and West Virginia, which were cutting principally ties and timbers with lumber as a secondary product. A companion report designated "Part I

Small Sawmill Utilization of Appalachian Hardwoods," has been issued and embodies the results of a similar study among the small operators cutting lumber only on and near the Pisgah National Forest in North Carolina.

The Bureaus of Plant Industry and Entomology, who were cooperators in the study for the purpose of determining the damaging effect of fungi and insect depredations on Appalachian hardwoods, plan to present the results of their work in separate reports.

DESCRIPTION OF STUDY AREA

The study was carried out on the Shenandoah National Forest on the Trout Run and Thorn Bottom drainages, which are a part of the Lost River Working Circle. The area comprised about 15,000 acres of rough mountain land that supported a light stand of mixed hardwoods and pine estimated at 20,000,000 board feet. For the most part the soil was rocky and contained very little organic matter. Fire had run over the area from time to time prior to the creation of the national forest. Many of the trees were fire-scarred and badly decayed, but there were enough healthy young trees which, if released from competition, would make good growth and provide the nucleus for another crop. The stand averaged about 1,500 board feet per acre and was made up of 75 per cent mixed oak, 9 per cent chestnut, 14 per cent pine, and 2 per cent other hardwoods, such as hickory, ash, and black gum. Small mills were the only practicable means of cutting the tract because of the light stand and low quality timber. (Fig. 5.)

The timber sale area on which this study was conducted was made by the Forest Service to a subsidiary of a large company. In addition to taking out the timber, the company also contracted to handle about 15,000 tons of chestnut oak bark on the area. The sale contract called for the cutting of not less than 80 per cent of all merchantable timber 12 inches and larger in diameter breast high, except in dead timber and chestnut where everything worth taking was removed. A tree was considered merchantable if it contained one or more logs and had a net scale equal to one-fourth of its gross scale volume. Any log, which was at least 8 feet long and 8 inches in diameter at the small end and which after deductions for visible indications of defect scaled one-third of the gross scale, was considered merchantable. Slash was lopped and scattered.

HOW THE WORK WAS DONE

A crew went into the woods and mills and studied the different species from the time the trees were cut in the woods to the time

Figure 5.--A light stand of hardwood with a small amount of pine on fairly rough country characterized the study area. Logs were skidded direct to the mill.

the ties, timbers, and lumber were loaded for shipment. It was planned to study the same logs in the mill as were studied in the woods, and to a reasonable degree this plan worked out. Such a plan is desirable because it permits of building up exact values for trees by merely adding up the results for the individual logs which came from them.

Species Studied and Character of Stand

Out of the many species that make up the Appalachian hardwoods, white oak (Quercus alba), red oak (Quercus borealis maxima), scarlet oak (Quercus coccinea), black oak (Quercus velutina), and chestnut oak (Quercus montana) comprised three-fourths of the stand studied and were given special consideration so that production costs, overrun, quality figures, and the like, would be obtained for each tree and log diameter class. The rest of the stand was made up of pitch pine (Pinus rigida), shortleaf pine (Pinus echinata), Virginia pine (Pinus virginiana), yellow poplar (Liriodendron tulipifera), chestnut (Castanea dentata), hickory (Hicoria sp.), sugar maple (Acer saccharum), basswood (Tilia sp.), black gum (Nyssa sylvatica), hemlock, (Tsuga sp.), cucumber magnolia (Magnolia acuminata), ash (Fraxinus sp.), butternut (Juglans cinerea), red maple (Acer rubrum), and black birch (Betula nigra). For these species, only log run information on overrun, percentage of defect, and the relative amount cut into lumber and ties was obtained.

From the list of species a general idea of the complexity of the stand may be formed. The percentage of each species varies from ridge to cove and from watershed to watershed. These changes make it difficult if not impossible to determine the exact volume distribution for each species without a 100 per cent cruise of the area. For this reason no attempt will be made to set up average figures on production costs, overrun, or the like, for the stand as a whole; instead weighted average values will be shown for each of the five oaks to which special attention was given. The volume distribution among the different diameter classes for each species of oak is based on the felling figures. Tables 1 and 2 give the volume distribution among the different diameter classes for the trees actually cut. The tables indicate that white oak and chestnut oak produced the largest logs and that scarlet oak produced the smallest. Tables 1 and 2 were used in computing weighted averages for each of the species.

Description of Mills

Four of the seven mills operating on the Trout Run-Thorn Bottom timber sale area on the Shenandoah National Forest were selected for study. Three of the mills studied were similar in equipment, but somewhat different in operating efficiency. The fourth mill was larger

Table 1.--Volume distribution of cut for trees by diameter classes and species on basis of net log scale

(Based on felling data obtained during study)

Diameter breast high	Volume distribution (net log scale)				
	Chestnut oak	White oak	Red oak	Scarlet oak	Black oak
Inches	Per cent	Per cent	Per cent	Per cent	Per cent
11			0.3	1.0	0.1
12	0.2	0.2	2.8	13.3	3.1
13	0.6	0.6	5.3	17.0	14.3
14	2.7	2.2	7.2	18.2	14.5
15	3.5	2.5	9.9	17.0	20.9
16	3.5	6.0	14.7	10.0	15.6
17	4.0	8.0	14.5	9.3	5.3
18	4.0	8.5	11.8	6.2	4.7
19	4.5	8.5	6.4	3.5	3.5
20	4.5	8.5	5.6	2.5	3.5
21	5.0	9.0	4.5	1.0	3.0
22	5.5	9.0	3.0	0.5	3.0
23	6.0	9.0	3.0	0.5	2.5
24	6.0	8.5	4.0		2.5
25	7.0	6.5	2.0		2.0
26	7.0	4.0	2.0		1.5
27	7.0	4.0	1.5		
28	8.0	2.5	1.0		
29	7.5	2.5	0.5		
30	7.5				
31	6.0				

Table 2.--Volume distribution of cut for trees by diameter classes and species on basis of mill tally

(Based on felling data obtained during study)

Diameter breast high	Volume distribution (mill tally)				
	Chestnut oak	White oak	Red oak	Scarlet oak	Black oak
Inches	Per cent	Per cent	Per cent	Per cent	Per cent
11		0.1	0.4	1.3	0.3
12	0.4	0.3	3.3	14.3	3.5
13	0.6	1.0	6.2	18.9	18.0
14	4.0	2.6	8.7	18.6	18.2
15	4.0	2.9	10.4	16.9	20.0
16	4.0	8.5	16.5	10.0	16.0
17	4.0	8.6	15.1	8.5	4.8
18	5.0	8.0	11.3	4.0	3.2
19	5.0	9.2	6.1	3.0	3.0
20	5.0	8.8	5.0	2.0	3.0
21	5.0	8.0	4.0	1.0	2.0
22	5.0	8.0	3.0	1.0	2.0
23	6.0	8.0	2.0	0.5	2.0
24	6.0	7.0	2.0		2.0
25	6.0	6.0	2.0		2.0
26	8.0	5.0	1.0		2.0
27	7.0	3.0	1.0		
28	7.0	3.0	1.0		
29	7.0	2.0	1.0		
30	6.0				
31	5.0				

than the three just mentioned. It consisted of stationary boiler and engine, headsaw, edger, trim saw, sawdust conveyor, and mechanical log turner. At the other mills the equipment consisted of a boiler and engine mounted on wheels and a headsaw rig and sawdust conveyor. For purposes of reference the large mill will be numbered 5, and the three smaller ones 6, 7, and 8.

All of the mills had circular, inserted-tooth headsaws cutting from 17/64-inch to 18/64-inch kerf. All, except Mill 5, did the edging on the headsaw. Ties, timbers, and lumber were piled in the yards or loaded at the mill direct onto cars, depending on the site of the mill and the availability of cars. Each of the mills employed from 4 to 10 men. The mills were very similar in the products produced, but quite different in efficiency. Mill 5 (fig. 6) was too large for the woods equipment and was out of logs a large part of the time. When this happened the crew was supposed to go into the woods and cut logs, but this plan did not work out well. Mills 6 and 7 were run with a minimum of men and separate from the logging. When the logs gave out, as sometimes happened, the mill men ordinarily went home and their wages stopped. Neither Mill 6 or Mill 7 was well maintained, however, and much time was lost owing to breakdowns. At Mill 8 both the woods and mill were under the direction of the same man. The mill was well kept and when it ran out of logs the crew was shifted to the woods where they helped replenish the supply of logs. This mill represents a reasonably efficient layout and has been used in establishing milling costs in this report.

The logging conditions on the different operations were quite similar and the cost and yield data from all operations have been combined for purposes of an average except in the case of the milling costs as previously explained. The products of all the mills were hauled to the main line railroad shipping point by a narrow gauge railroad. In many tie operations the product is delivered to the shipping point by trucks instead of by a narrow gauge railroad.

The main products of all the mills were cross ties, switch ties, and bridge timbers. Lumber was cut only because of necessity in connection with tie and timber manufacture.

Woods Study

Since it was desired to study the same logs in the woods and at the mill, it was necessary to time the felling crews that cut down enough trees to keep the mill in logs. One member of the study party accompanied each felling crew and timed each operation as the tree was felled and cut into logs. He also scaled the logs resulting from each tree and obtained measurements on diameter breast high, stump height, length of unused stem, and theoretically rebucked the tree if he

Figure 6.— Mill 5. This mill was too large for the logging equipment and was out of logs a good share of the time.

thought the log lengths as cut were incorrect. The logs from each tree were numbered so that they could be identified later at the mill. The time and volume figures when combined with the wages the men received made it possible to compute the cost per thousand board feet of making logs of different diameters from trees of different sizes.

Another member of the study party timed the skidding with a stop watch and scaled each log. Since more than one log was usually skidded at a time the cost of skidding logs by diameter classes was computed on the basis of the cost and volume of the average load in relation to the gross scale when skidding logs of equal volume but of different diameters. No hauling charges were incurred because the logs were generally skidded direct to the mill.

Circle tallies were made on cut-over areas to determine the amount of material left unutilized and the number and species of trees left standing.

Logs were scaled with a Scribner Decimal C log rule.

Mill Study

Two men made up the mill study crew. One man scaled, numbered, and obtained the woods number of the logs, drew diagrams of defects in logs, and timed the sawing of each log. The other graded and tallied the ties, timbers, and lumber from each log in accordance with rules of the National Hardwood Lumber Association and the tie specifications as adopted by the American Engineering Standards Committee.

The comparative cost of sawing ties, timbers, and lumber from logs of different sizes was computed on the basis of the actual time required by the mill to produce 1,000 board feet of the various products from logs of different diameters and species and the cost of running the mill for a corresponding period. Milling costs were based on the average headsaw time ratio of Mill 8 because it represented what was considered reasonable operating efficiency under average conditions.

Determination of Results for Trees

Grade values, volume, overrun, and production costs for trees were obtained in most instances by adding up these items for the logs which came from each tree. Where an occasional log was missing, instead of discarding the whole tree, figures for the missing log were supplied from a table giving the average value of logs by diameter classes and positions in the tree.

BASIS FOR RESULTS

This study is based on the felling and bucking of 853 trees, the skidding to the mill or landing of 45,540 board feet, log scale, and the milling of 180,867 board feet, mill tally.

AVERAGE PRICES FOR PRODUCTS

Table 3 gives the prices used in the study in computing the value of the products obtained from trees and logs of different sizes and species. The prices for standard ties and timbers are based on the average prices paid by four large railroads at the time the study was made. The prices for lumber, reject, and narrow gauge ties were obtained direct from the company on whose operations the study was made. On the basis of the prices shown in this table and the volume distribution used in the study the average value of the combined products from chestnut oak was $23.90 per thousand board feet, mill tally, white oak, $26.31; red oak, $25.16; scarlet oak, $23.44; and black oak $23.65.

AVERAGE PRODUCTION COSTS

Small sawmill operators do not keep books systematically. The company at whose sawmills this study was made have a large number of mills most of which are not on national forests. They lumped certain charges so that it was difficult to get costs which applied only to the mills on the national forests. Every effort, however, was made to get the best available cost data.

Tables 4 and 5 give the average cost on a net log scale and mill tally basis of producing ties, timber, and lumber from the five oaks covered by the study.

The felling and bucking costs were computed on the basis of the actual time required to do the work at all mills and an hourly rate of 30 cents which corresponded to the wage rate of the cooperating company.

Brush disposal cost was computed on the basis of the actual time required to do the work at all mills and an hourly rate of 30 cents.

Swamping and skidding were computed on the basis of the daily cost of a crew and its output. A crew cost $7.53 per day divided as follows: Teamster $3.00, one-half time of swamper $1.38, feed for

Table 15.--Black oak trees - production cost per thousand board feet NET LOG SCALE by diameter classes

Diameter breast high	Sawing	Brush disposal	Skidding and swamping	Milling	Further handling[1]	Supervision maintenance, etc.[2]	Total production costs
Inches							
11	$ 4.12	$1.70	$ 5.76	$ 4.04	$ 3.48	$ 6.58	$25.68
12	3.94	1.60	5.65	3.85	3.33	6.19	24.56
13	3.76	1.50	5.58	3.70	3.18	5.86	23.58
14	3.60	1.43	5.60	3.59	3.07	5.62	22.91
15	3.44	1.36	5.55	3.41	2.95	5.31	22.02
16	3.30	1.29	5.55	3.28	2.85	5.13	21.40
17	3.16	1.22	5.51	3.15	2.76	5.01	20.81
18	3.05	1.16	5.42	2.98	2.66	4.59	19.86
19	2.94	1.10	5.33	2.85	2.57	4.32	19.11
20	2.84	1.04	5.21	2.73	2.48	4.05	18.35
21	2.73	.98	5.10	2.67	2.39	3.82	17.69
22	2.64	.92	5.01	2.64	2.32	3.63	17.16
23	2.55	.86	4.89	2.63	2.24	3.45	16.62
24	2.48	.81	4.79	2.63	2.17	3.29	16.17
25	2.39	.77	4.70	2.65	2.09	3.14	15.74
26	2.32	.74	4.58	2.66	2.01	3.00	15.31
Weighted average	3.30	1.28	5.45	3.28	2.85	5.04	21.20

[1]Includes the following:
Loading ties and lumber at mills.
Hauling ties and lumber to railroad shipping point.
Loading, shipping, and inspection at railroad shipping point.
Piling ties and lumber at railroad shipping point.

[2]Includes the following:
Supervision.
Maintenance and depreciation of mill, railroad, and equipment.
Insurance.
Taxes.
Railroad construction.
Mill set-ups.

that otherwise would have gone into saw kerf. In addition, the scale rule can not anticipate the efficiency of the mill doing the work. The lumber from logs of differenct sizes therefore does not correspond to the log scale. The lumber tally may be greater or less than log scale and hence there is an overrun or an underrun. The gross overrun or gross underrun is the amount by which the mill tally overruns or underruns the gross log scale, respectively. Similarly the excess or deficit of mill tally over net log scale (gross log scale minus allowance for defect) is called net overrun or net underrun. The total mill tally for each log was obtained by adding side lumber produced and the volume of the ties and timbers, after having converted their contents to board feet on the basis of the merchantable content. The total mill tally thus obtained was compared to the log scale in order to determine overrun. Another factor which affects net overrun in Appalachian hardwoods is the large amount of defect and the difficulty of making a consistent deduction for it.

Since a large percentage of the small logs were cut into ties and timbers, it was logical to expect a large overrun. Tables 16 and 17 give the gross and net overrun for the different species by diameter classes. A glance shows that there is a wide variation in overrun among the different diameters for the same species. Small logs and trees have an extremely large overrun, whereas in some cases the large logs fail to cut out the log scale. Scarlet oak shows the largest average net overrun and white oak the smallest. This may be expected since the scarlet oak trees on the average were the smallest and the white oak trees the largest.

Small logs and trees cut out more footage in ties, timbers, and lumber per thousand board feet, log scale, than large logs and trees, and in this way reduce or offset the increased cost of handling them. This effect is illustrated in the following examples, which also show the method of converting net log scale costs to a mill tally basis. For example (Table 13), the cost of sawing per thousand board feet for 11-inch red oak trees is $4.12 and for 29-inch trees, $2.15. Reduced to a mill tally basis by dividing these costs by the overrun and underrun percentages and multiplying by 100 ($\frac{4.12}{170.5} \times 100 = 2.42$; $\frac{2.15}{84.0} \times 100 = 2.56$), these costs become $2.42 for 11-inch trees and $2.56 for 29-inch trees. In North Carolina mills cutting red oak into lumber it was found that for 14-inch trees the net overrun was about 20 per cent, whereas in this study where ties and timbers were the principal product the net overrun was 56 per cent. A part of this is due to lumber saved as a result of fewer saw cuts and the rest to the utilization of ties with sweep for which a deduction in scaling was made. In this study the percentage of the log cut into ties decreased and the percentage cut into lumber increased as the logs became larger. This, also, had the effect of reducing the overrun in the larger logs.

Table 16.—Variation of gross and net overrun and underrun and percentage of defect by diameter classes for logs for the various oaks studied

Top diameter inside bark	Chestnut oak			White oak			Red oak			Scarlet oak			Black oak			All oaks		
	Overrun		Defect	Overrun		Defect	Overrun		Defect	Overrun		Defect	Overrun		Defect	Overrun		Defect
	Net	Gross		Net	Gross		Net	Gross		Net	Gross		Net	Gross		Net	Gross	
Inches	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
8	165.0	125.0	15.1	165.0	120.0	17.0	170.0	135.0	13.0	167.0	130.0	13.8	160.0	140.0	7.7	165.0	130.0	15.0
9	125.0	66.0	26.2	113.0	83.0	14.1	95.0	68.0	13.8	95.0	76.0	9.7	111.0	90.0	9.9	100.0	72.0	14.0
10	95.0	47.0	24.6	80.0	63.0	9.4	67.0	51.0	9.6	68.0	57.0	6.5	80.0	68.0	6.6	70.0	50.0	11.8
11	70.0	35.0	20.6	57.0	43.0	8.9	53.0	40.0	8.5	53.0	42.0	7.2	61.0	51.0	6.2	56.0	37.0	11.5
12	52.0	25.0	17.8	41.0	33.0	5.7	45.0	31.0	9.6	42.0	30.0	8.4	48.0	35.0	8.8	44.0	28.0	11.1
13	42.0	19.0	16.2	33.0	25.0	6.0	38.0	25.0	9.4	33.0	19.0	10.5	37.0	23.0	10.2	34.0	19.0	11.2
14	35.0	14.0	15.5	27.0	20.0	5.5	32.0	19.0	9.8	23.0	7.0	13.0	29.0	15.0	10.8	26.0	11.0	11.9
15	29.0	11.0	13.9	22.0	15.0	5.7	26.0	14.0	9.5	14.0	-4.0	15.8	23.0	10.0	10.6	20.0	7.0	10.8
16	25.0	9.0	12.8	17.0	12.0	4.3	21.0	9.0	9.9	4.0	-14.0	17.3	19.0	6.0	10.9	16.0	4.0	10.3
17	22.0	6.0	13.1	13.0	8.0	4.4	17.0	5.0	10.2				16.0	4.0	10.3	15.0	2.0	9.3
18	19.0	4.0	12.6	10.0	5.0	4.5	12.0	1.0	9.8				13.5	2.0	10.1	15.0	1.0	9.8
19	16.0	2.0	12.0	8.0	2.5	5.1	8.0	-3.5	10.7				12.0	0	10.7	14.0	-2.0	10.7
20	14.0	0	12.2	5.0	0	4.7	4.0	-7.5	11.1				10.0	-2.0	10.9	13.0	-3.0	12.5
21	13.0	-2.0	13.3	3.0	-2.0	4.9	0	-11.5	11.5				10.0	-4.0	12.8	12.0	-4.0	13.4
22	11.0	-5.0	14.4	1.0	-4.0	4.9	-4.0	-15.0	11.4				9.0	-5.0	12.9	11.0	-5.0	12.7
23	10.0	-7.0	15.4	-1.0	-5.0	4.0	-7.0	-18.0	11.8				8.5	-7.0	14.3	9.0	-7.0	13.6
24	9.0	-9.0	16.5	-3.0	-8.5	5.7							7.5	-9.0	15.3	7.0	-9.0	13.6
25	7.0	-11.0	16.8	-5.0	-11.0	6.3										6.0	-11.0	14.5
26	5.0	-14.0	18.1	-6.0	-12.0	6.4										3.0	-13.0	15.1
Weighted average	21.6	2.1	16.1	27.7	11.4	12.8	37.2	21.7	11.3	57.9	40.4	11.1	49.8	39.4	6.9	36.4	20.0	12.1

Table 17.—Variation in gross and net overrun and underrun and percentage of defect by diameter classes for trees for the various oaks studied

Diameter breast high	Chestnut oak			White oak			Red oak			Scarlet oak			Black oak			All oaks		
	Overrun		Defect	Overrun		Defect	Overrun		Defect	Overrun		Defect	Overrun		Defect	Overrun		Defect
	Net	Gross		Net	Gross		Net	Gross		Net	Gross		Net	Gross		Net	Gross	
Inches	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
11	77.0	45.0	18.1	90.0	49.0	21.6	70.5	52.5	10.5	85.5	70.0	8.3	83.0	79.0	2.2	82.0	65.0	9.3
12	71.0	41.0	17.5	78.0	43.0	19.7	65.5	48.0	10.5	79.0	62.0	9.5	75.0	71.0	2.3	75.0	57.0	10.3
13	65.0	36.0	17.5	69.0	38.5	18.0	61.0	43.5	10.9	71.5	52.5	11.1	67.5	62.0	3.3	68.0	50.0	10.7
14	60.0	33.0	16.9	60.0	34.0	16.3	56.0	39.0	10.9	64.5	45.5	11.5	61.5	53.0	5.2	61.5	43.0	11.4
15	55.0	29.0	16.8	53.0	30.0	15.0	51.0	34.5	10.9	57.5	38.5	12.0	55.0	46.0	5.8	54.0	37.0	11.0
16	49.0	26.0	15.4	46.0	25.5	14.0	46.5	30.0	11.3	50.0	32.5	11.7	50.0	38.5	7.7	48.0	31.0	11.5
17	45.0	23.0	15.2	41.0	22.0	13.4	42.0	25.0	12.0	42.5	27.0	10.9	45.0	32.5	8.6	41.5	26.0	11.0
18	40.0	19.0	15.0	36.5	19.0	12.8	37.0	21.0	11.7	36.0	21.5	10.7	40.0	27.0	9.3	36.0	21.0	11.0
19	36.0	16.0	14.7	33.5	16.0	13.1	32.0	16.0	12.1	28.5	16.5	9.3	35.0	22.0	9.6	31.0	16.0	11.4
20	32.0	13.0	14.4	29.0	13.0	12.4	27.0	11.5	12.2	21.0	12.0	7.4	30.5	18.0	9.6	27.0	12.0	11.8
21	28.0	10.0	14.0	26.0	11.0	11.9	22.5	7.0	12.7	14.0	8.0	5.2	26.0	13.5	9.9	23.5	11.0	10.1
22	24.0	7.0	13.7	23.0	8.0	12.2	17.5	3.0	12.3	7.0	4.0	2.8	22.0	9.5	10.2	20.5	6.0	12.0
23	21.0	4.0	14.0	20.0	6.0	11.7	13.0	-2.0	13.3	0	1.0	-1.0	18.0	6.0	10.1	18.0	3.0	12.7
24	19.0	1.0	15.1	18.0	3.5	12.2	8.0	-6.5	13.4				14.0	2.0	10.5	16.5	1.0	13.3
25	16.0	-2.0	15.5	15.0	1.0	12.2	3.0	-11.0	13.6				10.0	-2.0	10.9	15.0	-1.5	14.3
26	13.0	-5.0	15.9	13.0	-1.0	12.4	-1.5	-15.5	14.2				6.0	-5.5	10.8	12.5	-3.5	15.4
27	10.0	-7.0	15.5	10.0	-2.5	11.4	-6.5	-19.0	13.4							9.5	-5.5	16.4
28	8.0	-10.0	16.7	8.0	-4.0	11.1	-11.0	-24.0	14.6							7.5	-7.5	17.8
29	6.0	-14.0	18.9	6.0	-6.0	11.3	-16.0	-29.0	15.5							5.5	-9.0	18.7
30	4.0	-18.0	21.1															
31	2.0	-22.0	23.5															
Weighted average	21.6	2.1	16.1	27.7	11.4	12.8	37.2	21.7	11.3	57.9	40.4	11.1	49.8	39.4	6.9	36.4	20.0	12.1

The percentage of defect by species is also shown. Defect as here used means rot, shake, check, fire damage, crook, sweep, or any other imperfection of the log for which a deduction in scale is made. Red oak, scarlet oak, and white oak were about on a par so far as the percentage of defect is concerned, while black oak was the least and chestnut oak the most defective.

Production Costs Per Thousand Board Feet Mill Tally for Logs and Trees of Different Diameters and Species

Production costs per thousand board feet mill tally by diameter classes for logs and trees for the five species of oak studied are shown in Tables 18 to 27.

The striking point about these tables is the effect that overrun has had in reducing the production cost ratio between small trees and large trees. The trend of the cost ratio between different diameters is also influenced to a large degree by the varying percentages of the logs of different sizes that are cut into ties and into lumber. This point will be considered further in connection with the products cut from trees of different sizes.

The effect of overrun and the effect of the varying percentages of different sized logs have operated in Tables 18 to 27 in such a way that there is only a small difference in the mill tally production costs between large trees and small trees for any of the species studied. In some instances, such as red oak, the production cost on a mill tally basis is actually greater for large trees than for small ones.

Another point to be noted in Tables 18 to 27 is that the average mill tally production costs for the five species of oaks studied are not far different from each other although the size of the timber varied considerably. This fact is due to the effect of overrun combining with the effect of the class of product into which the trees of different sizes were cut, and is an important consideration in establishing stumpage values and also has a bearing on a selective logging. From a profitable standpoint, the advantages of leaving small trees in the forest are much less important in tie operations than in lumber mills. The fact that trees put on their maximum usable growth per acre when nearing merchantable size and not as saplings, however, should be considered before cutting young stock for the production of ties and lumber.

Table 18.--Chestnut oak logs - production cost per thousand board feet MILL TALLY by diameter classes

Top diameter inside bark	Sawing	Brush disposal	Skidding and swamping	Milling	Further handling[1]	Supervision maintenance, etc.[2]	Total production costs
Inches							
8	$ 3.09	$0.75	$ 3.82	$ 2.34	$ 1.90	$ 4.01	$15.91
9	3.08	0.77	3.87	2.56	1.90	3.84	16.02
10	3.08	0.81	3.93	2.27	1.90	3.68	15.67
11	3.08	0.81	3.97	2.16	1.90	3.52	15.44
12	2.96	0.82	4.01	2.18	1.90	3.39	15.26
13	2.75	0.80	4.05	2.13	1.90	3.30	14.93
14	2.52	0.74	4.10	2.14	1.90	3.23	14.63
15	2.37	0.70	4.15	2.11	1.90	3.22	14.45
16	2.29	0.65	4.20	2.08	1.90	3.22	14.34
17	2.25	0.63	4.27	2.12	1.90	3.29	14.46
18	2.19	0.61	4.32	2.18	1.90	3.34	14.54
19	2.19	0.61	4.43	2.25	1.90	3.42	14.80
20	2.15	0.61	4.65	2.32	1.90	3.52	15.15
21	2.10	0.60	4.93	2.42	1.90	3.62	15.57
22	2.07	0.60	5.27	2.54	1.90	3.70	16.08
23	2.03	0.61	5.62	2.65	1.90	3.78	16.59
24	1.99	0.61	5.96	2.78	1.90	3.88	17.12
25	1.98	0.61	6.30	2.90	1.90	3.95	17.64
26	1.99	0.61	6.60	3.00	1.90	4.03	18.13
Weighted average	2.62	0.73	4.27	2.40	1.90	3.72	15.64

[1]Includes the following:
Loading ties and lumber at mills.
Hauling ties and lumber to railroad shipping point.
Loading, shipping, and inspection at railroad shipping point.
Piling ties and lumber at railroad shipping point.

[2]Includes the following:
Supervision.
Maintenance and depreciation of mill, railroad, and equipment.
Insurance.
Taxes.
Railroad construction.
Mill set-ups.

Table 19.--Chestnut oak trees - production cost per thousand board feet MILL TALLY by diameter classes

Diameter breast high	Sawing	Brush disposal	Skidding and swamping	Milling	Further handling[1]	Supervision maintenance, etc.[2]	Total production costs
Inches							
12	$ 3.90	$0.94	$ 3.87	$ 2.43	$ 1.90	$ 4.01	$17.05
13	3.76	0.91	3.92	2.42	1.90	3.95	16.86
14	3.58	0.89	3.93	2.38	1.90	3.81	16.49
15	3.42	0.88	3.97	2.35	1.90	3.74	16.26
16	3.29	0.87	3.98	2.29	1.90	3.65	15.98
17	3.10	0.84	3.99	2.23	1.90	3.54	15.60
18	2.96	0.83	4.04	2.20	1.90	3.48	15.41
19	2.82	0.81	4.06	2.17	1.90	3.43	15.19
20	2.69	0.79	4.08	2.17	1.90	3.36	14.99
21	2.58	0.77	4.11	2.18	1.90	3.38	14.92
22	2.52	0.74	4.14	2.20	1.90	3.41	14.91
23	2.43	0.71	4.16	2.23	1.90	3.46	14.89
24	2.39	0.68	4.21	2.27	1.90	3.52	14.97
25	2.37	0.66	4.26	2.33	1.90	3.61	15.13
26	2.35	0.65	4.32	2.40	1.90	3.69	15.31
27	2.35	0.65	4.35	2.45	1.90	3.77	15.47
28	2.35	0.66	4.44	2.54	1.90	3.92	15.81
29	2.32	0.66	4.60	2.69	1.90	4.11	16.28
30	2.32	0.66	4.81	2.85	1.90	4.33	16.87
31	2.31	0.67	5.00	3.03	1.90	4.55	17.46
Weighted average	2.62	0.73	4.27	2.40	1.90	3.72	15.64

[1]Includes the following:
Loading ties and lumber at mills.
Hauling ties and lumber to railroad shipping point.
Loading, shipping, and inspection at railroad shipping point.
Piling ties and lumber at railroad shipping point.

[2]Includes the following:
Supervision.
Maintenance and depreciation of mill, railroad, and equipment.
Insurance.
Taxes.
Railroad construction.
Mill set-ups.

Table 20.--White oak logs - production cost per thousand board feet MILL TALLY by diameter classes

Top diameter inside bark	Sawing	Brush disposal	Skidding and swamping	Milling	Further handling[1]	Supervision maintenance, etc[2]	Total production costs
Inches							
8	$ 3.00	$0.70	$ 2.64	$ 2.39	$ 1.90	$ 5.00	$15.63
9	3.15	0.75	2.79	2.32	1.90	4.65	15.56
10	3.26	0.80	2.92	2.05	1.90	4.28	15.21
11	3.18	0.83	4.02	2.04	1.90	3.90	15.87
12	3.06	0.84	4.09	2.05	1.90	3.69	15.63
13	2.86	0.82	4.12	2.02	1.90	3.55	15.27
14	2.68	0.79	4.14	2.03	1.90	3.47	15.01
15	2.56	0.77	4.15	2.03	1.90	3.45	14.86
16	2.46	0.74	4.15	2.03	1.90	3.47	14.75
17	2.39	0.73	4.14	2.08	1.90	3.51	14.75
18	2.36	0.71	4.12	2.16	1.90	3.55	14.80
19	2.35	0.69	4.10	2.23	1.90	3.61	14.88
20	2.38	0.68	4.08	2.32	1.90	3.67	15.03
21	2.39	0.65	4.06	2.42	1.90	3.71	15.13
22	2.42	0.62	4.03	2.51	1.90	3.77	15.25
23	2.44	0.62	4.00	2.59	1.90	3.81	15.36
24	2.49	0.60	3.97	2.77	1.90	3.87	15.60
25	2.54	0.59	3.94	2.90	1.90	3.94	15.81
26	2.55	0.59	3.91	2.93	1.90	4.00	15.88
Weighted average	2.77	0.78	4.11	2.24	1.90	3.63	15.43

[1]Includes the following:
Loading ties and lumber at mills.
Hauling ties and lumber to railroad shipping point.
Loading, shipping, and inspection at railroad shipping point.
Piling ties and lumber at railroad shipping point.

[2]Includes the following:
Supervision.
Maintenance and depreciation of mill, railroad, and equipment.
Insurance.
Taxes.
Railroad construction.
Mill set-ups.

Table 21.--White oak trees - production cost per thousand board feet MILL TALLY by diameter classes

Diameter breast high	Sawing	Brush disposal	Skidding and swamping	Milling	Further handling[1]	Supervision maintenance, etc.[2]	Total production costs
Inches							
11	$ 3.79	$0.89	$ 3.72	$ 2.68	$ 1.90	$ 4.82	$17.80
12	3.75	0.90	3.81	2.63	1.90	4.66	17.65
13	3.67	0.89	3.86	2.53	1.90	4.44	17.29
14	3.58	0.89	3.93	2.43	1.90	4.20	16.93
15	3.46	0.89	3.97	2.32	1.90	3.99	16.53
16	3.36	0.88	4.04	2.26	1.90	3.85	16.29
17	3.19	0.87	4.07	2.22	1.90	3.74	15.99
18	3.04	0.85	4.09	2.18	1.90	3.64	15.70
19	2.87	0.82	4.12	2.17	1.90	3.60	15.48
20	2.75	0.81	4.14	2.18	1.90	3.52	15.30
21	2.62	0.78	4.13	2.15	1.90	3.45	15.03
22	2.54	0.75	4.16	2.17	1.90	3.46	14.98
23	2.45	0.72	4.15	2.18	1.90	3.44	14.84
24	2.41	0.69	4.15	2.22	1.90	3.50	14.87
25	2.39	0.67	4.16	2.28	1.90	3.56	14.96
26	2.35	0.65	4.15	2.33	1.90	3.62	15.00
27	2.35	0.65	4.12	2.39	1.90	3.66	15.07
28	2.35	0.66	4.08	2.44	1.90	3.69	15.12
29	2.32	0.66	4.06	2.51	1.90	3.75	15.20
Weighted average	2.77	0.78	4.11	2.24	1.90	3.63	15.43

[1]Includes the following:
Loading ties and lumber at mills.
Hauling ties and lumber to railroad shipping point.
Loading, shipping, and inspection at railroad shipping point.
Piling ties and lumber at railroad shipping point.

[2]Includes the following:
Supervision.
Maintenance and depreciation of mill, railroad, and equipment.
Insurance.
Taxes.
Railroad construction.
Mill set-ups.

Table 22.--Red oak logs - production cost per thousand board feet MILL TALLY by diameter classes

Top diameter inside bark	Sawing	Brush disposal	Skidding and swamping	Milling	Further handling[1]	Supervision maintenance, etc.[2]	Total production costs
Inches							
8	$ 1.71	$0.74	$ 3.54	$ 2.24	$ 1.90	$ 4.11	$14.24
9	2.11	0.87	3.63	2.53	1.90	3.89	14.93
10	2.22	0.88	3.74	2.21	1.90	3.68	14.63
11	2.19	0.86	3.84	2.09	1.90	3.51	14.39
12	2.15	0.83	3.95	2.08	1.90	3.42	14.33
13	2.14	0.80	4.06	2.02	1.90	3.36	14.28
14	2.12	0.78	4.17	2.05	1.90	3.36	14.38
15	2.11	0.75	4.28	2.05	1.90	3.40	14.49
16	2.10	0.71	4.40	2.08	1.90	3.49	14.68
17	2.10	0.68	4.54	2.14	1.90	3.62	14.98
18	2.11	0.67	4.66	2.25	1.90	3.74	15.33
19	2.13	0.68	4.80	2.37	1.90	3.89	15.77
20	2.15	0.68	4.95	2.51	1.90	4.04	16.23
21	2.18	0.70	5.12	2.68	1.90	4.25	16.83
22	2.21	0.73	5.33	2.84	1.90	4.53	17.54
23	2.26	0.73	5.52	3.00	1.90	4.81	18.22
Weighted average	2.27	0.86	3.99	2.29	1.90	3.51	14.82

[1] Includes the following:
Loading ties and lumber at mills.
Hauling ties and lumber to railroad shipping point.
Loading, shipping, and inspection at railroad shipping point.
Piling ties and lumber at railroad shipping point.

[2] Includes the following:
Supervision.
Maintenance and depreciation of mill, railroad, and equipment.
Insurance.
Taxes.
Railroad construction.
Mill set-ups.

Table 23.--Red oak trees - production cost per thousand board feet MILL TALLY by diameter classes

Diameter breast high	Sawing	Brush disposal	Skidding and swamping	Milling	Further handling[1]	Supervision maintenance, etc.[2]	Total production costs
Inches							
11	$ 2.42	$1.00	$ 3.62	$ 2.45	$ 1.90	$ 3.87	$15.24
12	2.38	0.97	3.66	2.39	1.90	3.77	15.07
13	2.34	0.93	3.71	2.35	1.90	3.70	14.93
14	2.31	0.92	3.76	2.31	1.90	3.60	14.80
15	2.28	0.90	3.81	2.28	1.90	3.52	14.69
16	2.25	0.88	3.86	2.25	1.90	3.47	14.61
17	2.23	0.86	3.94	2.23	1.90	3.43	14.58
18	2.23	0.85	3.98	2.18	1.90	3.37	14.51
19	2.23	0.83	4.07	2.19	1.90	3.36	14.58
20	2.24	0.82	4.14	2.21	1.90	3.34	14.65
21	2.23	0.80	4.21	2.23	1.90	3.36	14.73
22	2.25	0.78	4.28	2.28	1.90	3.40	14.89
23	2.26	0.76	4.40	2.38	1.90	3.49	15.17
24	2.30	0.75	4.50	2.44	1.90	3.56	15.45
25	2.32	0.75	4.62	2.55	1.90	3.70	15.84
26	2.36	0.75	4.75	2.70	1.90	3.81	16.27
27	2.43	0.77	4.83	2.83	1.90	3.91	16.67
28	2.49	0.80	5.01	3.04	1.90	4.11	17.35
29	2.56	0.83	5.21	3.27	1.90	4.38	18.15
Weighted average	2.27	0.86	3.99	2.29	1.90	3.51	14.82

[1]Includes the following:
Loading ties and lumber at mills.
Hauling ties and lumber to railroad shipping point.
Loading, shipping, and inspection at railroad shipping point.
Piling ties and lumber at railroad shipping point.

[2]Includes the following:
Supervision.
Maintenance and depreciation of mill, railroad, and equipment.
Insurance.
Taxes.
Railroad construction.
Mill set-ups.

Table 24.--Scarlet oak logs - production cost per thousand board feet MILL TALLY by diameter classes

Top diameter inside bark	Sawing	Brush disposal	Skidding and swamping	Milling	Further handling[1]	Supervision maintenance, etc.[2]	Total production costs
Inches							
8	$ 1.61	$0.67	$ 3.25	$ 2.29	$ 1.90	$ 3.72	$13.44
9	2.05	0.83	3.40	2.41	1.90	3.55	14.14
10	2.19	0.88	3.56	2.13	1.90	3.41	14.07
11	2.22	0.88	3.71	2.06	1.90	3.26	14.03
12	2.24	0.86	3.85	2.09	1.90	3.14	14.08
13	2.27	0.86	3.98	2.13	1.90	3.05	14.19
14	2.31	0.85	4.13	2.28	1.90	2.99	14.46
15	2.35	0.82	4.26	2.44	1.90	2.97	14.74
16	2.46	0.83	4.40	2.64	1.90	3.00	15.23
Weighted average	2.20	0.87	3.66	2.21	1.90	3.29	14.13

[1]Includes the following:
Loading ties and lumber at mills.
Hauling ties and lumber to railroad shipping point.
Loading, shipping, and inspection at railroad shipping point.
Piling ties and lumber at railroad shipping point.

[2]Includes the following:
Supervision.
Maintenance and depreciation of mill, railroad, and equipment.
Insurance.
Taxes.
Railroad construction.
Mill set-ups.

Table 25.--Scarlet oak trees - production cost per thousand board feet MILL TALLY by diameter classes

Diameter breast high	Sawing	Brush disposal	Skidding and swamping	Milling	Further handling[1]	Supervision maintenance, etc.[2]	Total production costs
Inches							
11	$ 2.22	$0.92	$ 3.33	$ 2.35	$ 1.90	$ 3.65	$14.37
12	2.30	0.89	3.40	2.30	1.90	3.56	14.25
13	2.19	0.87	3.52	2.28	1.90	3.47	14.23
14	2.19	0.87	3.60	2.21	1.90	3.34	14.11
15	2.18	0.86	3.70	2.16	1.90	3.21	14.01
16	2.20	0.86	3.78	2.11	1.90	3.09	13.94
17	2.22	0.86	3.86	2.10	1.90	2.99	13.93
18	2.24	0.85	3.95	2.13	1.90	2.96	14.03
19	2.29	0.86	4.03	2.17	1.90	2.95	14.20
20	2.35	0.86	4.13	2.21	1.90	3.00	14.45
21	2.39	0.86	4.21	2.26	1.90	3.01	14.63
22	2.47	0.86	4.37	2.32	1.90	3.06	14.88
23	2.55	0.86	4.38	2.37	1.90	3.07	15.13
Weighted average	2.20	0.87	3.66	2.21	1.90	3.29	14.13

[1]Includes the following:
Loading ties and lumber at mills.
Hauling ties and lumber tc railroad shipping point.
Loading, shipping, and inspection at railroad shipping point.
Piling ties and lumber at railroad shipping point.

[2]Includes the following:
Supervision.
Maintenance and depreciation of mill, railroad, and equipment.
Insurance.
Taxes.
Railroad construction.
Mill set-ups.

Table 26.--Black oak logs - production cost per thousand board feet MILL TALLY by diameter classes

Top diameter inside bark	Sawing	Brush disposal	Skidding and swamping	Milling	Further handling[1]	Supervision maintenance, etc.[2]	Total production costs
Inches							
8	$ 2.25	$0.93	$ 3.16	$ 2.19	$ 1.90	$ 3.58	$14.01
9	2.24	0.91	3.27	2.24	1.90	3.54	14.10
10	2.23	0.90	3.45	1.99	1.90	3.49	13.96
11	2.21	0.87	3.64	1.93	1.90	3.44	13.99
12	2.19	0.84	3.82	2.01	1.90	3.34	14.10
13	2.18	0.81	3.97	2.06	1.90	3.16	14.08
14	2.17	0.76	4.11	2.12	1.90	2.99	14.05
15	2.17	0.72	4.22	2.13	1.90	2.89	14.03
16	2.16	0.70	4.34	2.14	1.90	2.84	14.08
17	2.15	0.67	4.42	2.16	1.90	2.80	14.10
18	2.14	0.65	4.49	2.23	1.90	2.80	14.21
19	2.13	0.64	4.56	2.29	1.90	2.77	14.29
20	2.12	0.62	4.62	2.37	1.90	2.75	14.38
21	2.10	0.61	4.67	2.47	1.90	2.73	14.48
22	2.09	0.59	4.72	2.54	1.90	2.72	14.56
23	2.08	0.58	4.76	2.65	1.90	2.70	14.67
Weighted average	2.20	0.85	3.64	2.20	1.90	3.37	14.16

[1] Includes the following:
Loading ties and lumber at mills.
Hauling ties and lumber to railroad shipping point.
Loading, shipping, and inspection at railroad shipping point.
Piling ties and lumber at railroad shipping point.

[2] Includes the following:
Supervision.
Maintenance and depreciation of mill, railroad, and equipment.
Insurance.
Taxes.
Railroad construction.
Mill set-ups.

Table 27.--Black oak trees - production cost per thousand board feet MILL TALLY by diameter classes

Diameter breast high	Sawing	Brush disposal	Skidding and swamping	Milling	Further handling[1]	Supervision maintenance, etc[2]	Total production costs
Inches							
11	$ 2.25	$0.93	$ 3.15	$ 2.21	$ 1.90	$ 3.60	$14.04
12	2.25	0.91	3.23	2.20	1.90	3.54	14.03
13	2.24	0.90	3.33	2.21	1.90	3.50	14.08
14	2.23	0.89	3.47	2.22	1.90	3.48	14.19
15	2.22	0.88	3.58	2.20	1.90	3.43	14.21
16	2.20	0.86	3.70	2.19	1.90	3.42	14.27
17	2.18	0.84	3.80	2.17	1.90	3.35	14.24
18	2.18	0.83	3.87	2.13	1.90	3.28	14.19
19	2.19	0.81	3.95	2.11	1.90	3.20	14.15
20	2.18	0.80	3.99	2.09	1.90	3.10	14.06
21	2.17	0.78	4.05	2.12	1.90	3.03	14.05
22	2.16	0.75	4.11	2.16	1.90	2.98	14.06
23	2.16	0.73	4.14	2.23	1.90	2.92	14.08
24	2.18	0.71	4.20	2.31	1.90	2.89	14.19
25	2.17	0.70	4.27	2.41	1.90	2.85	14.30
26	2.19	0.70	4.32	2.51	1.90	2.83	14.45
Weighted average:	2.20	0.85	3.64	2.20	1.90	3.37	14.16

[1] Includes the following:
Loading ties and lumber at mills.
Hauling ties and lumber to railroad shipping point.
Loading, shipping, and inspection at railroad shipping point.
Piling ties and lumber at railroad shipping point.

[2] Includes the following:
Supervision.
Maintenance and depreciation of mill, railroad, and equipment.
Insurance.
Taxes.
Railroad construction.
Mill set-ups.

Tie, Timber, and Lumber Grades

During the investigation the ties and timbers were classified in accordance with specifications of the American Engineering Standards Committee and the lumber was graded under the rules of the National Hardwood Lumber Association and the rules of the Southern Pine Association.

For ready reference the grade, size, and contents in board feet for crossties are shown here:

Grade	Size	Contents board feet
1	6"x6"x8-1/2'	26
2	6"x7"x8-1/2'	30
3	6"x8"x8-1/2'	34
3	7"x7"x8-1/2'	35
4	7"x8"x8-1/2'	40
5	7"x9"x8-1/2'	45

Switch ties for the most part were cut in cross-section 7"x9" and in varying lengths. Most of the bridge timbers were 8"x11" in cross-section and varied in length from 9 to 22 feet.

Reject ties as here classified represented all sizes of ties and included those that were not acceptable to the large railroad to whom all of the good ties were sold. Most of these ties were rejected because of small rotten spots in them. They were disposed of to a short line railroad whose industrial life was limited. Narrow gauge ties were ties too rotten or too small to be of value as rejects and were used by the cooperating company in its own railroad. To make sure that the grading of the output of these small mills was in accordance with commercial practice, conferences were had with the inspectors who classified and accepted the output of the small mills at the railroad shipping point. In this way points of difference in the interpretation of the railroad specifications and the grading rules were cleared up.

Tables 28 to 32 give the percentage of each class of product for the five species of oak by diameter classes. The lack of quality in the timber is reflected in a measure by the small amount of lumber which graded No. 1 Common and better and the large percentage of reject ties. The volume of reject ties varied from 23.9 in scarlet oak to only 9.3 per cent in white oak. The small logs yielded little lumber but a high footage of ties, while for large logs the reverse is true. For example, only 9.4 per cent of the volume of 10-inch chestnut oak logs was cut into lumber, while 90.6 per cent went into ties. In the case of 24-inch logs of the same species 65.4 per cent of the volume was sawed into lumber and 34.6 per cent into ties. In tie operations, as will be brought out in connection with log values, large logs do not have the same advantage

Table 28.—Percentages of ties, timbers, and lumber by diameter classes for chestnut oak logs

Top diameter inside bark	Lumber						Ties								
							Cross						Switch		
	Firsts and Seconds	Selects	No. 1 Common	No. 2 Common	Sound Wormy	No. 3 Common	1	2	3	4	5	Reject	9 feet to 17 feet	Bridge	Narrow gauge
Inches	Per cent of material in each grade														
8			4.1	2.0		6.1	39.6	30.4				17.8			
9	2.0			.9	0.9	1.1	5.7	23.1	26.1	4.4	9.9	25.9			
10			1.0	1.9	1.1	5.4	.8	12.1	14.8	13.6	5.6	37.2	6.5		
11			1.9	2.4	5.7	5.8		1.8	5.1	20.3	22.9	24.0	8.8		1.3
12	.1		3.8	4.6	7.3	10.6		.5		9.2	14.7	19.5	29.3		.4
13	.1		3.5	5.6	13.0	9.4			1.2	2.9	20.9	17.5	24.6	1.3	
14	.4	0.3	4.5	6.7	17.2	12.6					11.6	13.6	27.8	5.3	
15		.2	5.4	7.6	23.3	11.9					7.9	14.8	18.8	10.1	
16	.1		5.4	5.0	25.9	14.3					4.0	14.4	21.6	8.8	.5
17	.1		4.9	9.2	26.2	13.3			.8	.9	3.2	17.6	14.0	9.8	
18	.3		4.7	8.7	25.2	18.1					2.3	13.9	8.4	18.4	
19	.5	.3	4.2	12.0	31.8	9.9						10.9	16.1	14.3	
20	1.5		7.2	7.0	32.1	9.8			1.5		2.9	13.4	14.9	9.7	
21	.9		5.2	8.8	29.5	11.5					3.7	14.0	16.2	10.2	
22	1.5		5.4	18.1	31.1	14.2					2.1	15.5	7.9	4.2	
23	.5		2.9	11.9	24.3	11.0						12.6	26.9	5.2	4.7
24			7.2	17.4	18.0	22.8						11.1	21.4		2.1
26			7.7	16.2	27.7	26.9							21.5		
Weighted average	.4	.1	4.4	7.2	19.5	11.6	.3	1.3	1.8	3.2	8.3	17.0	18.3	6.3	.3

Table 29.--Percentages of ties, timbers, and lumber by diameter classes for white oak logs

Top diameter inside bark	Lumber						Ties									
							Cross						Switch			
	Firsts and Seconds	Selects	No. 1 Common	No. 2 Common	Sound Wormy	No. 3 Common	1	2	3	4	5	Reject	9 feet to 17 feet	Over 17 feet	Bridge	Narrow gauge
Inches	Per cent of material in each grade															
7							24.3	28.0				47.7				
8							41.0	31.6				27.4				
9				1.2	0.3	2.8	18.0	24.8	4.0	11.8	10.7	26.4				
10			2.3	2.9	2.9	5.7	1.8	17.2	5.7	16.2	9.1	33.9	2.3			
11	0.4	0.3	4.0	5.0	2.4	7.5		3.2	3.6	9.3	17.2	18.0	25.8	2.5		0.8
12	.3	.3	6.5	8.2	4.1	6.9		.5	1.0	4.3	15.8	14.6	32.2	1.8	1.3	2.2
13	.4	.3	7.7	11.3	7.6	7.9		.4		1.0	10.3	11.8	36.1	1.4	3.8	
14	1.8	.1	8.5	12.0	6.7	15.4		.3	.4		10.0	6.3	30.3	1.2	6.6	.4
15	2.7	1.2	13.3	12.6	9.8	9.2					3.2	7.2	28.6	2.8	8.8	.6
16	2.3	.1	9.6	12.7	15.1	12.5					3.8	3.4	24.3	4.2	12.0	
17	4.2	.2	15.8	14.7	14.1	11.8				.5	2.1	2.8	14.8	3.7	13.8	1.5
18	7.7	.5	18.8	8.0	16.0	9.5						4.5	26.8		8.2	
19	3.7		9.0	10.2	26.1	24.8					1.9	2.7	18.4		3.2	
20	17.8	12.0	7.2	23.3	3.5	6.8						6.4	23.0			
21	4.8	2.4	7.9	9.7	29.5	13.6					7.3	3.4	21.4			
22	6.2		21.0	16.5	7.1	3.5						12.6	33.1			
23	4.3		14.4	6.6	24.6	11.2						10.2	28.7			
24			3.6	3.8	54.0	9.6					8.1	"	20.9			
26	7.2		41.7	22.3		13.0							15.8			
27	10.4	8.4	9.6	3.9								14.9	52.8	"		
28			8.3	20.4		12.7							46.8			11.8
Weighted average	2.5	.6	10.0	10.7	10.2	10.4	.6	1.8	.7	2.1	7.1	9.3	25.4	1.9	6.1	.6

Table 30.--Percentages of ties, timbers, and lumber by diameter classes for red oak logs

Top diameter inside bark	Lumber						Ties								
							Cross						Switch		
	Firsts and Seconds	Selects	No. 1 Common	No. 2 Common	Sound Wormy	No. 3 Common	1	2	3	4	5	Reject	9 feet to 17 feet	Bridge	Narrow gauge
Inches	Per cent of material in each grade														
7												100.0			
8							16.7	15.4	4.3	15.4		48.2			
9			0.7	1.8	0.1	3.5	13.1	25.2	10.3	10.8	3.0	28.9	1.8		0.8
10	0.1	0.1	2.1	5.8	.1	6.9		6.5	8.7	18.2	10.7	30.8	9.6		.4
11	.4	.5	8.5	5.7	.4	4.7			3.3	11.0	15.4	22.1	28.0		
12	1.5	.7	9.8	8.4	.6	5.1			1.2	.9	10.5	11.3	49.3		.7
13	3.2	1.6	15.9	12.3	.5	7.1				.7	5.5	14.6	38.6		
14	7.5	1.9	20.8	9.9	.2	4.6					5.0	6.7	41.3	2.1	
15	9.5	.6	20.9	12.5	2.1	10.4			1.0		5.4	6.6	31.0		
16	8.0	.6	21.4	18.7		7.8					5.2	10.6	27.7		
17	11.3	1.6	25.7	9.7	.9	11.7			2.2	2.5	5.8	12.4	16.2		
18	5.2	.9	19.2	16.2	3.5	17.9		1.6			9.4	12.7	10.9		2.5
19	16.2	2.7	30.2	12.5		2.2					3.9		32.3		
20	9.4	4.4	29.5	20.0	3.4	16.1						13.8	3.4		
21	48.4	2.0	26.1	2.0									21.5		
23	3.4		42.7	15.5	16.5	21.9									
Weighted average	4.2	1.0	13.5	9.5	.8	6.9	1.1	2.7	2.5	4.8	7.9	16.2	28.4	.2	.3

Table 31.--Percentages of ties, timbers, and lumber by diameter classes for scarlet oak logs

Top diameter inside bark	Lumber						Ties								
							Cross					Reject	Switch		Narrow gauge
	Firsts and Seconds	Selects	No. 1 Common	No. 2 Common	Sound Wormy	No. 3 Common	1	2	3	4	5		9 feet to 17 feet		
Inches	Per cent of material in each grade														
8				1.2		9.2	8.7	10.0				65.0			5.9
9			0.2	1.1		1.9	5.1	11.8	10.6	19.6	4.4	39.0	4.5		1.8
10			1.4	3.5		2.4		2.9	4.6	17.5	15.9	31.6	19.6		.6
11	0.1		4.2	6.3	0.1	4.3	.4		1.1	3.9	14.0	19.5	45.7		.4
12	.1		7.2	10.3		9.5				.8	6.4	7.6	58.1		
13			9.9	16.2	.2	7.4		1.6			2.4	17.6	44.7		
14		0.5	11.7	25.8		8.8					13.4		39.8		
15			13.8	24.2		8.3					6.9	8.0	38.8		
16			6.2	28.6		14.6					50.6				
Weighted average	.1	.0	4.1	7.2	.0	4.9	1.2	3.2	3.4	9.2	10.4	23.9	31.7		.7

Table 32.--Percentages of ties, timbers, and lumber by diameter classes for black oak logs

Top diameter inside bark	Lumber						Ties								
							Cross						Switch		
	Firsts and Seconds	Selects	No. 1 Common	No. 2 Common	Sound Wormy	No. 3 Common	1	2	3	4	5	Reject	9 feet to 17 feet	Bridge	Narrow gauge
Inches	Per cent of material in each grade														
7												100.0			
8		1.2		2.5		9.4		29.6				44.5	12.8		
9			0.3	2.2		6.0	5.4	10.3	9.3	27.4	12.4	24.0			2.7
10	0.1	.1	2.2	2.6	0.1	5.9	.5	2.4	6.8	20.9	12.7	25.5	19.8		.4
11		.2	5.6	5.7	.3	4.0			1.8	7.4	14.4	16.8	43.8		
12	1.4	.7	6.0	8.3	.2	8.0			1.1	2.6	17.3	21.5	32.1		.8
13	1.4	.6	10.8	10.1	.3	11.5					11.6	18.1	35.6		
14	2.4	.3	5.4	9.0	.9	18.3			1.4		14.3	19.4	27.6		1.0
15	.9		11.2	18.5	.4	24.7					7.3	7.3	29.7		
16	1.4	.6	12.7	12.6	5.4	25.2					2.3	17.6	22.2		
17	8.1	1.3	16.8	14.6		21.7						8.3	29.2		
18	8.6	•	17.8	14.3		10.7						21.5	11.8	15.3	
19				17.2		57.3						25.5			
21	8.9	2.2	21.1	25.8		8.3							33.7		
22				11.1		37.3						51.6			
23	9.6		38.1	6.6								45.7			
Weighted average	1.5	.4	7.3	8.5	.6	11.9	.4	1.5	2.4	7.0	10.8	19.6	27.3	.4	.4

in quality over small ones as they do in straight lumber operations, principally because ties from small logs, size for size, are worth just as much as ties from large logs. Large logs, of course, are somewhat more valuable if sound because the larger sizes of ties and timbers can be cut from them.

Trees show the same trends as logs (Tables 33 to 37). Here again the small trees were cut principally into ties, while in the larger diameters the percentage of each tree cut into ties decreased and the amount of lumber increased. The distribution of ties and lumber among the different diameter classes is such that the spread in value will be only about one-third as much as in lumber operations.

The combined value of the different products for each species by diameter classes is given in Tables 43 to 47.

Production Costs and the Combined Value of Ties, Timbers, and Lumber Compared

Tables 38 to 47 give a comparison of the production cost and the combined value of the products by diameter classes on a net log scale and mill tally basis for each of the five species of oak studied.

The extremely high value of the product from small trees on a net log scale basis is due to the high overrun. For example, the products (ties, timbers, and lumber) from 12-inch chestnut oak trees on a net log scale basis (Table 38) are worth $39.84 per thousand board feet, but on a mill tally basis only $23.30 (Table 43). This explains the wide variation among the different diameter classes in the value of the product on a net log scale basis. On a mill tally basis there is little difference in the value of the product between small trees and large trees. Reference to Table 43 shows that the value of the product from 12-inch chestnut oak trees is $23.30 and from 25-inch trees only $24.00. In red oak the spread is more for the same diameters and amounts to $6.00. This is due to a lower percentage of rejects and a higher percentage of No. 1 Common and also to the better grade of lumber in the red oak than in the chestnut oak. As previously noted, ties from small trees, size for size, are worth just as much as from large trees and the timber studied was of rather poor quality, particularly the large trees, with the result that the normal quality difference between the various sizes was further reduced. These factors explain the lack of a spread in value between small and large trees shown in this case. In the lumber operations studied in North Carolina red oak showed a spread in value of $13.40 between trees 13 inches in diameter and trees 25 inches in diameter. The disparity between the results for the two studies is due for the most part to the fact that small trees cut out first class ties, but only common lumber, and, too, the timber studied in North Carolina was of much better quality than that studied in West Virginia.

Table 33.--Percentages of ties, timbers and lumber by diameter classes for chestnut oak trees

Diameter breast high	Lumber						Ties								
							Cross						Switch		
	Firsts and Seconds	Selects	No. 1 Common	No. 2 Common	Sound Wormy	No. 3 Common	1	2	3	4	5	Reject	9 feet to 17 feet	Bridge	Narrow gauge
Inches	Per cent of material in each grade														
12	1.3						1.3	11.8	14.5	55.3	5.3	10.5			
13			3.4	6.7						89.9					
14	.3		1.7	4.7	3.4	4.2	2.5	6.4	11.9	5.2	19.4	24.3	15.4	0.3	0.3
15	.2		4.8	3.9	1.3	2.3	.4	3.0	3.9	3.6	19.6	20.3	36.7		
16	.4		5.6	6.2	3.6	3.8	.1	3.3	1.7	5.4	25.4	21.5	22.9		.1
17	.5		8.3	5.0	7.7	4.6		.1	.6	6.1	4.8	38.7	21.4	2.1	.1
18		2.3	8.1	8.8	3.0	5.3			.1	1.1	25.7	15.6	7.3	22.7	
19			9.9	7.0	8.4	8.1				4.6	10.6	23.8	26.5	1.1	
20			5.6	10.4	12.7	11.3		.1	.2	1.8	9.1	20.4	16.7	11.4	.3
21			6.1	14.1	7.8	13.3			.2	.2	10.3	20.9	27.1		
22		.7	5.6	11.3	17.1	6.6	.1	1.7	1.9	2.5	9.4	16.3	5.6	21.1	.1
23	.2		5.3	9.7	26.9	9.7			.2	.2	6.4	14.2	18.3	8.9	
24	.4		3.5	8.4	23.1	13.3			.2	.2	3.7	20.4	11.3	15.4	.1
25			10.5	10.1	25.5	10.3			.5	.5	5.5	4.6	18.9	13.6	
26	.9		2.4	10.6	33.5	7.0					5.8	9.6	6.7	23.5	
27	3.4		11.1	8.9	27.9	9.0					5.6	12.3	8.8	13.0	
28	.1		4.8	14.0	30.9	8.6					2.2	13.7	3.7	21.9	.1
29	.8		4.5	7.1	29.0	21.7				1.1	2.6	11.5	17.6	4.0	.1
30	.9		4.6	8.6	38.8	4.7			.3	.3	.7	15.4	6.8	18.9	
31	1.1		6.1	12.1	29.1	11.5					2.3	6.8	11.0	15.6	4.4
Weighted average	.4	.1	4.4	7.2	19.5	11.6	.3	1.3	1.8	3.2	8.3	17.0	18.3	6.3	.3

Table 34.--Percentages of ties, timbers, and lumber by diameter classes for white oak trees

Diameter breast high	Lumber						Ties								
							Cross						Switch		
	Firsts and Seconds	Selects	No. 1 Common	No. 2 Common	Sound Wormy	No. 3 Common	1	2	3	4	5	Reject	9 feet to 17 feet	Over 17 feet	Bridge	Narrow gauge
Inches	Per cent of material in each grade															
10																
11								18.8	31.2	12.5	12.5	25.0				
12						3.1			96.9							
13			3.3	6.7		9.5		3.1	9.5	9.5		20.1	18.9		19.4	
14			2.4	4.1	2.4	1.9		.6	10.8	13.0	23.0	8.9	32.6	0.2		0.1
15	1.2	0.3	2.3	5.0	1.7	9.0		2.2	5.5	3.8	16.5	21.6	30.3	.6		
16	1.1	.3	4.3	6.9	5.3	4.5		3.2	15.0	3.9	10.0	11.2	27.0	6.9	.4	0
17	.8	.1	9.0	9.7	4.9	5.0		.3	3.6	5.1	12.0	12.1	32.5	3.4	.3	1.2
18	.4	1.1	8.5	12.3	3.5	7.5		.3	2.1	2.3	12.9	12.7	34.1	.1	.5	1.7
19	.8	.5	7.1	8.6	12.4	9.4	0.5		1.7	1.5	10.8	6.6	26.1	3.2	10.7	.1
20	.8	.2	5.2	11.3	14.5	10.5		.0	1.6	2.0	3.6	7.0	31.6		10.9	.8
21	1.8	.5	9.2	12.3	13.5	10.2		0	1.2	.5	2.7	3.2	37.1	.5	7.1	.2
22	4.0	.3	10.7	11.7	13.6	17.1				2.8	3.5	1.5	19.0	8.7	7.1	
23	5.0	.4	15.2	9.5	14.0	13.8		.1	.4	.2	2.8	3.1	28.1	1.8	6.1	.5
24	1.4	0	7.6	15.1	15.1	18.7			.2	.3	3.7	6.5	20.7	4.6	6.5	
25	.3	0	4.9	18.5	15.4	20.9		.1	1.9	2.0	2.4	4.9	21.7	.4	6.6	
26	3.5		13.6	17.5	16.2	12.0			.1	.2	6.7	9.3	13.2		6.0	1.7
27	6.9	4.0	23.8	19.8		3.1					8.7		30.2		3.5	
28	1.6		13.0	16.3	21.4	20.8					1.7	6.5	18.7			
29			3.5	7.1	24.6	35.6					2.4		26.8			
34	7.5		41.7	22.2		13.0							15.6			
35						43.6									56.4	
36	7.9	4.9	20.3	12.2		9.3						11.4	32.2			1.8
44													79.8			20.2
Weighted average	2.5	.6	10.0	10.7	10.2	10.4	.6	1.8	.7	2.1	7.1	9.3	25.4	1.9	6.1	1.6

Table 35.--Percentages of ties, timbers, and lumber by diameter classes for black oak trees

Diameter breast high	Lumber						Ties								
							Cross					Reject	Switch	Bridge	Narrow gauge
	Firsts and Seconds	Selects	No. 1 Common	No. 2 Common	Sound Wormy	No. 3 Common	1	2	3	4	5		9 feet to 17 feet		
Inches	Per cent of material in each grade														
11				3.2		9.7	32.3					41.9	12.9		
12				5.7	2.3	20.6	1.4	11.0	2.3	25.7	2.8	15.6	12.6		
13	0.3		2.1	2.4	.8	1.2	2.8	6.4	10.3	26.9	7.1	20.5	18.4		0.8
14	.1	0.3	5.4	3.0	.4	4.2	.4	3.1	8.9	19.9	13.8	11.2	29.3		
15	.6	.5	5.0	6.3		3.3	.2	4.3	2.2	11.7	11.4	11.4	42.4		.7
16	1.2	1.4	8.9	7.0	.4	4.2	.1	.3	.6	6.8	6.9	7.5	54.7		
17	.2		3.7	9.6	.2	6.7	.5	1.3	1.5	5.1	14.0	24.5	32.7		
18	2.6		6.5	8.1		7.8		3.2			14.6	17.1	40.1		
19	2.7	.3	9.5	9.8		9.2			.3	6.7	11.6	20.0	29.7		.2
21			14.3	19.0		27.0							39.7		
22	3.4		26.1	18.7		9.2			.8		7.9	2.0	25.7	6.2	
24				12.9		34.1							53.0		
26	8.4	2.1	19.2	17.6		25.0					7.1		20.6		
30	7.2		31.4	11.3		4.5							45.6		
Weighted average	1.5	.4	7.3	8.5	.6	11.9	.4	1.5	2.4	7.0	10.8	19.6	27.3	.4	.4

Table 36.--Percentages of ties, timbers, and lumber by diameter classes for red oak trees

Diameter breast high	Lumber						Ties							
							Cross						Switch	
	Firsts and Seconds	Selects	No.1 Common	No.2 Common	Sound Wormy	No.3 Common	1	2	3	4	5	Reject	9 feet to 17 feet	Narrow gauge
Inches	Per cent of material in each grade													
11						1.1	9.7	16.1	5.4	49.5	2.1	16.1		
12			2.0	1.6		2.1	3.5	12.4	17.3	26.4	13.0	12.6	9.1	
13			3.5	5.3	0.1	8.0	5.4	11.2	12.2	10.1	7.5	22.8	13.9	
14	0.6	0.3	4.0	3.5		5.1	2.9	7.1	5.5	17.6	9.2	22.3	20.9	1.0
15	0.3	0.3	9.0	6.8	0	4.7	1.7	3.7	4.8	9.2	6.5	20.4	32.6	0
16	1.9	0.8	10.6	8.4	0.3	2.6	0.4	1.4	1.1	3.4	9.6	23.4	36.1	0
17	2.2	1.8	11.7	5.9	0.2	2.9	0.8	1.0	1.1	2.6	7.7	15.9	46.1	0.1
18	4.0	0.8	14.8	11.2	0	2.5	1.0	0.1	1.5	3.5	4.4	16.8	37.3	2.1
19	4.7	1.3	13.8	12.5	0.2	3.5	0.7	3.1	0.6	1.3	6.8	10.9	40.5	0.1
20	5.2	2.3	27.9	10.8		2.8				0.1	13.3	0.6	37.0	
21	7.9		20.1	13.4		8.6					10.7	13.3	26.0	
22	4.6		27.0	11.2	13.0							18.2	26.0	
23	11.3	1.6	20.7	10.6	1.1	11.0		0.7	0.9	1.6	10.3	16.0	12.0	2.2
24	10.4	6.8	25.9	14.2	3.5	12.4						15.4	11.4	
26	6.1	1.2	28.4	21.8	4.0	22.1		0.3			0.4	6.4	5.0	4.3
29	34.8	2.4	33.2	10.3		6.6							12.7	
Weighted average	4.2	1.0	13.5	9.5	0.8	6.9	1.1	2.7	2.5	4.8	7.9	16.2	28.4	0.3

Table 37.--Percentages of ties, timbers, and lumber by diameter classes for scarlet oak trees

Diameter breast high	Lumber						Ties								
							Cross						Switch		
	Firsts and Seconds	Selects	No.1 Common	No.2 Common	Sound Wormy	No.3 Common	1	2	3	4	5	Reject	9 feet to 17 feet		Narrow gauge
Inches	Per cent of material in each grade														
10												100.0			
11			1.8	2.1		0.9	1.8	22.8	1.2	25.7	0.6	19.7	22.8		0.6
12			0.8	1.7		2.8	5.1	8.9	11.0	17.6	7.0	30.2	14.5		0.4
13			1.9	3.2		3.4	2.8	6.7	3.3	17.1	11.3	21.7	27.7		0.9
14			3.2	6.0		4.1	0.2	1.7	5.2	10.1	11.2	18.7	39.1		0.5
15			4.9	7.1		5.3	0.4	2.2	2.1	6.4	9.1	17.8	43.8		0.9
16			5.9	10.3		7.0			0	0.1	7.3	28.4	40.1		0.9
17		0.1	7.1	16.6		6.8		1.5	0	1.9	16.9	3.2	45.9		
18		0.2	8.5	17.4	0.5	11.4		0.2	0.2	6.1	3.5	8.5	43.5		
19		0.2	10.9	21.2		7.5		1.5	0.3	1.5	2.9	7.3	46.7		
20			9.1	18.0		8.5				0.6	21.0	31.1	11.7		
21			8.5	30.3		15.3					45.9				
23			2.2	0.8		4.6			9.5	10.8		12.2	59.9		
Weighted average		0.1	4.1	7.2	.0	4.9	1.2	3.2	3.4	9.2	10.4	23.4	31.7		0.7

Table 38.--Difference between production cost and value of ties, timbers, and lumber from logs and trees of different diameters for chestnut oak - NET LOG SCALE

Logs				Trees			
Top diameter inside bark	Total production cost per M feet net log scale[1]	Value of product per M net log scale	Difference per M feet	Diameter breast high	Total production cost per M feet net log scale[1]	Value of product per M net log scale	Difference per M feet
Inch.				Inch.			
8	$ 42.18	$ 61.34	$19.16				
9	36.03	52.31	16.28				
10	30.56	45.53	14.97				
11	26.26	39.95	13.65				
12	23.20	35.87	12.67	12	$ 29.13	$ 39.84	$10.71
13	21.19	33.65	12.46	13	27.81	38.53	10.72
14	19.76	32.13	12.37	14	26.37	37.44	11.07
15	18.63	30.83	12.20	15	25.17	36.42	11.25
16	17.93	29.87	11.94	16	23.78	35.09	11.31
17	17.65	29.28	11.63	17	23.61	34.22	11.61
18	17.30	28.62	11.32	18	21.56	33.11	11.55
19	17.17	28.01	10.84	19	20.62	32.23	11.61
20	17.26	27.59	10.33	20	19.77	31.35	11.68
21	17.59	27.40	9.81	21	19.06	30.46	11.40
22	17.86	26.97	9.11	22	18.47	29.57	11.10
23	18.24	26.78	8.54	23	18.00	28.92	10.92
24	18.66	26.54	7.88	24	17.79	28.50	10.71
25	18.87	26.11	7.24	25	17.53	27.84	10.31
26	19.04	25.67	6.63	26	17.29	27.18	9.89
				27	17.02	26.51	9.49
				28	17.05	26.08	9.03
				29	17.24	25.65	8.41
				30	17.52	25.17	7.65
				31	17.79	24.74	6.95
Wt. aver.	19.02	29.06	10.04	Wt. aver.	19.02	29.06	10.04

[1]Excluding selling cost, stumpage, and margin for profit and risk.

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Table 39.--Difference between production cost and value of ties, timbers, and lumber from logs and trees of different diameters for white oak - NET LOG SCALE

Logs				Trees			
Top diameter inside bark	Total production cost per M feet net log scale[1]	Value of product per M net log scale	Difference per M feet	Diameter breast high	Total production cost per M feet net log scale[1]	Value of product per M net log scale	Difference per M feet
Inch.				Inch.			
8	$ 41.43	$ 55.65	$14.22				
9	33.16	48.99	15.83				
10	27.38	43.56	16.18				
11	24.92	39.33	14.41	11	$ 33.83	$ 42.18	$ 8.35
12	22.05	36.24	14.19	12	31.41	41.12	9.71
13	20.33	34.78	14.45	13	29.23	40.05	10.82
14	19.07	33.53	14.46	14	27.10	38.88	11.78
15	18.15	32.45	14.30	15	25.30	37.94	12.64
16	17.28	31.24	13.98	16	23.78	36.94	13.16
17	16.68	30.51	13.83	17	22.55	36.10	13.55
18	16.29	29.98	13.69	18	21.43	35.35	13.92
19	16.08	29.75	13.67	19	20.63	34.91	14.28
20	15.78	29.03	13.25	20	19.73	33.93	14.20
21	15.59	28.63	13.04	21	18.93	33.39	14.46
22	15.41	28.18	12.77	22	18.42	32.84	14.42
23	15.20	27.72	12.52	23	17.81	32.16	14.35
24	15.14	27.26	12.12	24	17.54	31.86	14.32
25	15.03	26.79	11.76	25	17.20	31.22	14.02
26	14.94	26.56	11.62	26	16.96	30.85	13.89
				27	16.59	30.14	13.55
				28	16.34	29.70	13.36
				29	16.10	29.26	13.16
Wt. aver.	19.70	33.60	13.90	Wt. aver.	19.70	33.60	13.90

[1] Excluding selling cost, interest on capital investment, stumpage, and margin for profit and risk.

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Table 40.--Difference between production cost and value of ties, timbers, and lumber from logs and trees of different diameters for red oak - NET LOG SCALE

Logs				Trees			
Top diameter inside bark	Total production cost per M feet net log scale[1]	Value of product per M net log scale	Difference per M feet	Diameter breast high	Total production cost per M feet net log scale[1]	Value of product per M net log scale	Difference per M feet
Inch.				Inch.			
8	$ 38.47	$ 54.00	$15.53				
9	29.11	41.54	12.43				
10	24.47	38.24	13.77				
11	22.04	37.26	15.22	11	$ 25.97	$ 36.32	$10.35
12	20.77	36.83	16.06	12	24.94	36.24	11.30
13	19.70	36.09	16.39	13	24.03	36.39	12.36
14	18.98	35.24	16.26	14	23.08	36.50	13.42
15	18.24	34.02	15.78	15	22.18	36.39	14.21
16	17.76	33.09	15.33	16	21.41	36.26	14.85
17	17.53	32.35	14.82	17	20.69	35.86	15.17
18	17.17	31.25	14.08	18	19.87	35.28	15.41
19	17.01	30.13	13.12	19	19.24	34.58	15.34
20	16.90	29.22	12.32	20	18.60	33.78	15.18
21	16.82	28.15	11.33	21	18.04	32.95	14.91
22	16.83	27.07	10.24	22	17.50	31.96	14.46
23	16.94	26.27	9.33	23	17.14	31.08	13.94
				24	16.69	29.92	13.23
				25	16.32	28.74	12.42
				26	16.02	27.53	11.51
				27	15.60	26.18	10.58
				28	15.45	25.01	9.56
				29	15.26	23.69	8.43
Wt. aver.	20.32	34.52	14.20	Wt. aver.	20.32	34.52	14.20

[1]Excluding selling cost, interest on capital investment, stumpage, and margin for profit and risk.

Table 41.--Difference between production cost and value of ties, timbers, and lumber from logs and trees of different diameters for scarlet oak - NET LOG SCALE

Logs				Trees			
Top diameter inside bark	Total production cost per M: feet net log scale[1]	Value of product per M net log scale	Difference per M feet	Diameter breast high	Total production cost per M feet net log scale[1]	Value of product per M net log scale	Difference per M feet
Inch.				Inch.			
8	$ 35.89	$ 55.54	$19.65				
9	27.58	42.61	15.03				
10	23.63	38.56	14.93				
11	21.47	36.72	15.25	11	$ 26.65	$ 39.51	$12.86
12	20.00	35.00	15.00	12	25.52	39.38	13.86
13	18.86	33.32	14.46	13	24.42	38.67	14.25
14	17.78	31.00	13.22	14	23.22	38.16	14.94
15	16.82	28.73	11.91	15	22.08	37.48	15.40
16	15.85	26.21	10.36	16	20.90	36.45	15.55
				17	19.84	35.20	15.36
				18	19.09	34.00	14.91
				19	18.24	32.32	14.08
				20	17.48	30.49	13.01
				21	16.69	28.73	12.04
				22	15.91	26.96	11.05
				23	15.13	25.20	10.07
Wt. aver.	22.31	37.01	14.70	Wt. aver.	22.31	37.01	14.70

[1] Excluding selling cost, interest on capital investment, stumpage, and margin for profit and risk.

Table 42.--Difference between production cost and value of ties, timbers, and lumber from logs and trees of different diameters for black oak - NET LOG SCALE

Logs				Trees			
Top diameter inside bark	Total production cost per M feet net log scale[1]	Value of product per M net log scale	Difference per M feet	Diameter breast high	Total production cost per M feet net log scale[1]	Value of product per M net log scale	Difference per M feet
Inch.				Inch.			
8	$ 33.95	$ 50.70	$16.75				
9	28.52	43.47	14.95				
10	24.55	38.70	14.15				
11	22.27	35.90	13.63	11	$ 25.68	$ 33.86	$ 8.18
12	20.69	34.19	13.50	12	24.56	35.35	10.79
13	19.13	32.61	13.48	13	23.58	36.10	12.52
14	17.88	31.60	13.72	14	22.91	36.50	13.59
15	16.96	30.87	13.91	15	22.02	36.42	14.40
16	16.34	30.52	14.18	16	21.40	36.45	15.05
17	15.97	30.39	14.42	17	20.81	35.96	15.15
18	15.69	30.30	14.61	18	19.86	35.28	15.42
19	15.59	30.46	14.87	19	19.11	34.49	15.38
20	15.45	30.47	15.02	20	18.35	33.67	15.32
21	15.61	31.02	15.41	21	17.69	32.89	15.20
22	15.59	31.17	15.58	22	17.16	32.21	15.05
23	15.68	31.46	15.78	23	16.62	31.39	14.77
				24	16.17	30.55	14.38
				25	15.74	29.70	13.96
				26	15.31	28.83	13.52
Wt. aver.	21.20	35.43	14.23	Wt. aver.	21.20	35.43	14.23

[1]Excluding selling cost, interest on capital investment, stumpage, and margin for profit and risk.

Table 43.--Difference between production cost and value of ties, timbers, and lumber from logs and trees of different diameters for chestnut oak - MILL TALLY

Logs				Trees			
Top diameter inside bark	Total production cost per M feet mill tally[1]	Value of product per M feet mill tally	Difference per M feet	Diameter breast high	Total production cost per M feet mill tally[1]	Value of product per M feet mill tally	Difference per M feet
Inches:				Inches:			
8	$ 15.91	$ 23.15	$ 7.24				
9	16.02	23.25	7.23				
10	15.67	23.35	7.68				
11	15.44	23.50	8.06	11	--	--	--
12	15.26	23.60	8.34	12	$ 17.05	$ 23.30	$ 6.25
13	14.93	23.70	8.77	13	16.86	23.35	6.49
14	14.63	23.80	9.17	14	16.49	23.40	6.91
15	14.45	23.90	9.45	15	16.26	23.50	7.24
16	14.34	23.95	9.61	16	15.98	23.55	7.57
17	14.46	24.00	9.54	17	15.60	23.60	8.00
18	14.54	24.05	9.51	18	15.41	23.65	8.24
19	14.80	24.15	9.35	19	15.19	23.70	8.51
20	15.15	24.20	9.05	20	14.99	23.75	8.76
21	15.57	24.25	8.68	21	14.92	23.80	8.88
22	16.08	24.30	8.22	22	14.91	23.85	8.94
23	16.59	24.35	7.76	23	14.89	23.90	9.01
24	17.12	24.35	7.23	24	14.97	23.95	8.98
25	17.64	24.40	6.76	25	15.13	24.00	8.87
26	18.13	24.45	6.32	26	15.31	24.05	8.74
				27	15.47	24.10	8.63
				28	15.81	24.15	8.34
				29	16.28	24.20	7.92
				30	16.87	24.20	7.33
				31	17.46	24.25	6.79
Wt. aver.	15.64	23.90	8.26	Wt. aver.	15.64	23.90	8.26

[1] Excluding selling cost, interest on capital investment, stumpage, and margin for profit and risk.

Table 44.--Difference between production cost and value of ties, timbers, and lumber from logs and trees of different diameters for white oak - MILL TALLY

Logs				Trees			
Top diameter inside bark	Total production cost per M feet mill tally[1]	Value of product per M feet mill tally	Difference per M feet	Diameter breast high	Total production cost per M feet mill tally[1]	Value of product per M feet mill tally	Difference per M feet
Inch.				Inch.			
8	$ 15.63	$ 21.00	$ 5.37				
9	15.56	23.00	7.44				
10	15.21	24.20	8.99				
11	15.87	25.05	9.18	11	$ 17.80	$ 22.20	$ 4.40
12	15.63	25.70	10.07	12	17.65	23.10	5.45
13	15.27	26.15	10.88	13	17.29	23.70	6.41
14	15.01	26.40	11.39	14	16.93	24.30	7.37
15	14.86	26.60	11.74	15	16.53	24.80	8.27
16	14.75	27.00	12.25	16	16.29	25.30	9.01
17	14.75	27.25	12.50	17	15.99	25.60	9.61
18	14.80	27.40	12.60	18	15.70	25.90	10.20
19	14.88	27.55	12.67	19	15.48	26.15	10.67
20	15.03	27.65	12.62	20	15.30	26.30	11.00
21	15.13	27.80	12.67	21	15.03	26.50	11.47
22	15.25	27.90	12.65	22	14.98	26.70	11.72
23	15.36	28.00	12.64	23	14.84	26.80	11.96
24	15.60	28.10	12.50	24	14.87	27.00	12.13
25	15.81	28.20	12.39	25	14.96	27.15	12.19
26	15.88	28.25	12.37	26	15.00	27.30	12.30
				27	15.07	27.40	12.33
				28	15.12	27.50	12.38
				29	15.20	27.60	12.40
Wt. aver.	15.43	26.31	10.88	Wt. aver.	15.43	26.31	10.88

[1]Excluding selling cost, interest on capital investment, stumpage, and margin for profit and risk.

Table 45.--Difference between production cost and value of ties, timbers, and lumber from logs and trees of different diameters for red oak - MILL TALLY

Logs				Trees			
Top diameter inside bark	Total production cost per M feet mill tally[1]	Value of product per M feet mill tally	Difference per M feet	Diameter breast high	Total production cost per M feet mill tally[1]	Value of product per M feet mill tally	Difference per M feet
Inch.				Inch.			
8	$ 14.24	$ 20.00	$ 5.76				
9	14.93	21.30	6.37				
10	14.63	22.90	8.27				
11	14.39	24.35	9.96	11	$ 15.24	$ 21.30	$ 6.06
12	14.33	25.40	11.07	12	15.07	21.90	6.83
13	14.28	26.15	11.87	13	14.93	22.60	7.67
14	14.38	26.70	12.32	14	14.80	23.40	8.60
15	14.49	27.00	12.51	15	14.69	24.10	9.41
16	14.68	27.35	12.67	16	14.61	24.75	10.14
17	14.98	27.65	12.67	17	14.58	25.25	10.67
18	15.33	27.90	12.57	18	14.51	25.75	11.24
19	15.77	28.00	12.23	19	14.58	26.20	11.62
20	16.23	28.10	11.87	20	14.65	26.60	11.95
21	16.83	28.15	11.32	21	14.73	26.90	12.17
22	17.54	28.20	10.66	22	14.89	27.20	12.31
23	18.22	28.25	10.03	23	15.17	27.50	12.33
				24	15.45	27.70	12.25
				25	15.84	27.90	12.06
				26	16.27	27.95	11.68
				27	16.67	28.00	11.33
				28	17.35	28.10	10.75
				29	18.15	28.20	10.05
Wt. aver.	14.82	25.16	10.34	Wt. aver.	14.82	25.16	10.34

[1]Excluding selling cost, interest on capital investment, stumpage, and margin for profit and risk.

Table 46.--Difference between production cost and value of ties, timbers, and lumber from logs and trees of different diameters for scarlet oak - MILL TALLY

Logs				Trees			
Top diameter inside bark	Total production cost per M feet mill tally[1]	Value of product per M feet mill tally	Difference per M feet	Diameter breast high	Total production cost per M feet mill tally[1]	Value of product per M feet mill tally	Difference per M feet
Inch.				Inch.			
8	$ 13.44	$ 20.80	$ 7.36				
9	14.14	21.85	7.71				
10	14.07	22.95	8.88				
11	14.03	24.00	9.97	11	$ 14.37	$ 21.30	$ 6.93
12	14.08	24.65	10.57	12	14.25	22.00	7.75
13	14.19	25.05	10.86	13	14.23	22.55	8.32
14	14.46	25.20	10.74	14	14.11	23.20	9.09
15	14.74	25.20	10.46	15	14.01	23.80	9.79
16	15.23	25.20	9.97	16	13.94	24.30	10.36
				17	13.93	24.70	10.77
				18	14.03	25.00	10.97
				19	14.20	25.15	10.95
				20	14.45	25.20	10.75
				21	14.63	25.20	10.57
				22	14.88	25.20	10.32
				23	15.13	25.20	10.07
Wt. aver.	14.13	23.44	9.31	Wt. aver.	14.13	23.44	9.31

[1]Excluding selling cost, interest on capital investment, stumpage, and margin for profit and risk.

Table 47.--Difference between production cost and value of ties, timbers, and lumber from logs and trees of different diameters for black oak - MILL TALLY

Logs				Trees			
Top diameter inside bark	Total production cost per M feet mill tally[1]	Value of product per M feet mill tally	Difference per M feet	Diameter breast high	Total production cost per M feet mill tally[1]	Value of product per M feet mill tally	Difference per M feet
Inch.				Inch.			
8	$ 14.01	$ 19.30	$ 5.29				
9	14.10	20.90	6.80				
10	13.96	22.45	8.49				
11	13.99	23.80	9.81	11	$ 14.04	$ 18.50	$ 4.46
12	14.10	24.95	10.85	12	14.03	20.20	6.17
13	14.08	25.20	11.12	13	14.08	21.55	7.47
14	14.05	26.40	12.35	14	14.19	22.60	8.41
15	14.03	26.90	12.87	15	14.21	23.50	9.29
16	14.08	27.30	13.22	16	14.27	24.30	10.03
17	14.10	27.60	13.50	17	14.24	24.80	10.56
18	14.21	27.85	13.64	18	14.19	25.20	11.01
19	14.29	28.10	13.81	19	14.15	25.55	11.40
20	14.38	28.35	13.97	20	14.06	25.80	11.74
21	14.48	28.50	14.02	21	14.05	26.10	12.05
22	14.56	28.75	14.19	22	14.06	26.40	12.34
23	14.67	29.00	14.33	23	14.08	26.60	12.58
				24	14.19	26.80	12.61
				25	14.30	27.00	12.70
				26	14.45	27.20	12.75
Wt. aver.	14.16	23.65	9.49	Wt. aver.	14.16	23.65	9.49

[1]Excluding selling cost, interest on capital investment, stumpage, and margin for profit and risk.

With the volume distribution among the different diameter classes found in this study, the average value of the five species of oak studied are: White oak, $26.31 per thousand board feet, mill tally; red oak, $25.16; chestnut oak, $23.90; black oak, $23.65; and scarlet oak, $23.44.

The figures in the tables indicate that for the conditions studied and with the prices used, 11-inch trees yield a fair profit if no charges are made for stumpage. In white oak, for example (Table 44), if a 20 per cent margin for profit and risk is allowed on the production cost for 11-inch trees there is still 84 cents per thousand board feet, mill tally, available for stumpage.

These examples bear out the statement previously made that tie operations can profitably use small trees and practice close utilization, but they can also skin the land of small trees that are just in their prime for growth. The skinning of land by tie operations can not be stopped on the ground that there is a loss in handling small timber, which is the case in straight lumber operations. There must be some other good reason for leaving the small trees, such as a desire to keep the land fully productive or to perpetuate a stand of trees on a given area with the idea of growing a future crop of high quality timber or the fact that large trees yield more profit than small ones. Theoretically tie requirements should be supplied from low quality trees and parts of high quality trees that yield only common lumber. In practice a combined operation of this kind is not so easily handled, but it can be done with profit as evinced by the many operators who produce both ties and high quality lumber.

If the owner does not wish to carry on a combined lumber and tie operation but wants to grow trees for ties alone, then a much shorter rotation is possible and a larger number of trees can be grown per acre. The application of this principle would come in cases where all the larger timber is cut and nothing is left on the ground except trees below tie size.

Log-Run Data for Miscellaneous Species.--In the description of the stand previously given, attention was called to a number of species for which only a small amount of information was obtained because individually they were of minor importance in the stand. Table 48 gives some figures on overrun, defect, and the like, for 13 species. The data are by no means complete as compared to that obtained for the five oaks. Yellow pine includes pitch pine, shortleaf pine, and Virginia pine. Except for yellow poplar and hemlock all of the 13 species were cut into ties. The maple was subject to a heart rot and it was seldom that a maple log was sound enough for tie production. The hickory was of fairly good quality, but no attempt was made to market it in any other way than as ties.

Table 48.--Number of logs per M, percentages of ties, timbers, and lumber, gross and net overrun and underrun, and percentage of defect for the miscellaneous species studied

Species	Net log scale	Logs per M	Ties and timbers	Lumber	Overrun		Defect
					Net	Gross	
	Bd. ft.	Number	Per cent	Per cent	Per cent	Per cent	Per cent
Yellow pine[1]	18,950	15.3	27.0	73.0	28.8	23.4	4.2
Yellow poplar	9,000	10.2	00.0	100.0	6.7	- 2.4	8.5
Chestnut	7,260	35.1	88.9	11.1	32.9	17.1	11.9
Hickory	7,111	17.9	74.9	20.1	28.6	18.9	7.5
Sugar maple	3,010	18.3	67.9	32.1	7.8	0.2	7.1
Basswood	2,111	20.4	22.4	77.6	18.4	- 3.5	18.5
Black gum	1,390	37.4	90.3	9.7	52.7	25.6	17.7
Hemlock	1,330	6.8	00.0	100.0	24.5	23.6	0.7
Cucumber	860	16.3	10.0	90.0	10.2	9.0	1.1
White ash	700	28.6	76.7	23.3	43.0	17.8	17.7
Butternut	190	26.3	87.4	12.6	41.6	28.1	9.5
Red maple	70	42.9	88.6	11.4	74.7	36.6	22.2
Black birch	60	50.0	95.1	4.9	36.7	36.7	00.0

[1] Includes pitch pine, shortleaf pine, and Virginia pine.

The marketing of the miscellaneous species was somewhat of a problem. The ties were not first class but presented less of a problem than the side lumber. The best of the ties were sold to the same company that purchased the oak ties. The rejects were either used in the logging company's own narrow gauge railroad or else sold to a small extent to a shortline railroad. The lumber was disposed of locally as far as possible. In addition the company used some of the lumber in construction work and also shipped a small amount. From a forestry standpoint, the miscellaneous species must be cut. From the operator's standpoint they are a nuisance and detract from the desirability of the timber chance and must be considered in setting up stumpage values for the timber as a whole.

WOODS PRACTICE

Woods practice, in so far as it affects the perpetuation of a stand of timber on the area being logged, depends on the objective of the owner and the condition of the timber that is being worked. In this study the government owned the land and timber and wanted to put the stand in the best possible condition to grow another crop of timber and at the same time salvage the values in a deteriorating investment. As opposed to this there are cases where the operator owns the timber only and has free reign in cutting it, or an owner who owns both land and timber and desires to get all he can off the land because he has no interest in growing a second crop. Under such conditions a tie operator could do a first-class job of skinning the land, thereby bringing about a condition where the land would not be fully occupied in growing a crop; where erosion of the soil would probably result, and where the chances for another cut would be so remote that private capital would not be interested and the reproduction of a crop of timber would have to be brought about through public agencies. But this condition need not obtain if timber owners are willing to sacrifice a small amount of immediate returns in order to insure another crop and another return in the future.

The Forest Service, of course, has a permanent interest in the Shenandoah National Forest and therefore is desirous of putting the stands in the best possible growing condition so that in time sustained yield operations for the forest can be developed. To do this the stands must be cleared of defective and undesirable species, and the timber that is deteriorating must be cut. In so far as is possible timber sales are made in areas most in need of silvicultural treatment. The stand on the study area contained many overmature, defective, and stagnated trees that had to be removed to provide growing space for thrifty young timber on the ground and for reproduction through natural reseeding. In carrying out the provisions of this cutting practice the forester in charge of the sale marks the trees to be removed. This is a task that requires training and experience, particularly in Appalachian hardwoods. On the study area about 80 per cent of the volume

of all trees 12 inches in diameter and over was marked for cutting. Trees below 12 inches in diameter were taken if defective and some thrifty trees above 12 inches were left for seedling purposes and to make up volume for the next cut. Clinging rigidly to a diameter limit in marking is not desirable nor good forestry in most cases. Trees should be cut or left depending on their thrift, soundness, and need in the next cut. For example, on the study area all chestnut that was merchantable was taken regardless of size, because the species is doomed to the blight. Marking practice in mixed stands in so far as possible favors certain species, for example, oak is preferred to black gum.

Stand Cut and Left on Study Area

Tables 1 and 2 show the relative size of the trees removed. These two tables when considered in connection with Table 49, which shows the species and sizes of trees left standing, give an idea of the cutting practice. Even though the stand of timber before cutting was considered of poor quality it is striking that by a careful selection of the trees to be left the terms of the timber sale contract were met and yet 107 thrifty young trees varying in size from 4 inches to 21 inches were left on each acre. (Fig. 7.) One hundred and seven trees per acre is not a heavy stocking, of course, but it does augur well for a future crop of timber from the area. Table 49 is based on 26 plots that were well distributed over the area. These data bring out the possibilities as well as the limitations of marking to establish the species desired. For example, white oak is preferred to hickory, yet there are more hickory trees per acre than of white oak. Oak was favored as far as possible in preference to hickory, but even so it will require careful marking to reduce the hickory in the future stands because there are many small trees of this species. Red maple is another species of lower value than the oaks, which should be cut out as closely as possible in order to give more room to the preferred species. These are illustrative of the kind of problems that face a forester in correctly marking mixed stands of Appalachian hardwoods for cutting.

Good silviculture demands the cleaning up of these stands. In some cases the need is so great that the government carries on sanitation cutting on timber sale areas after the commercial logging has been completed. Such work removes unmerchantable and diseased trees of both desirable and undesirable species. On this particular sale area the contract stipulated that the purchaser remove from the forest an average of one unmerchantable tree per acre. Eight per cent of the trees cut were unmerchantable. Based on the number of unmerchantable trees actually cut, chestnut oak comes first, then white oak, black oak, scarlet oak, and red oak.

Table 49.--Number of trees left standing on the cut-over area[1]

Diameter breast high	Oak					Hickory	Red maple	Yellow poplar	White pine	Yellow pine[2]	Others[3]
	Chestnut	White	Red	Scarlet	Black						
Inch:	N	u	m	b	e	r	o	f	t	r e e	s
4	20	38	11	2	18	40	32		4	2	23
5	22	16	12	7	14	44	11		2	1	19
6	22	14	19	8	16	15	3		2	3	19
7	12	6	11	4	7	6	2	2		2	5
8	11	3	7	9	11		1			2	5
9	5	8	11	10	6	9	2	2	1	2	8
10	10	3	11	13	5	1			1	4	3
11	2	4	7	1	3	1		1		2	
12	8	2	4	3	5	3		1		1	2
13	3	2	8		2			2			2
14	5	4	2			1		5			1
15			2			1		1			
16								1			
17											
18								1			
19								1			
20											
21								1			
Total:	120	100	105	57	87	121	51	18	10	19	87
Av.No. per acre:	17	14	14	8	12	17	7	2	1	3	12

[1]The cut-over area comprised 26 sample plots totalling 7-1/4 acres.

[2]Includes pitch pine, shortleaf, and Virginia pine.

[3]Includes black gum, black locust, birch, chestnut, cucumber magnolia, dogwood, white oak, sycamore, and butternut.

Figure 7.-- By careful cutting an excellent stand of young trees can often be left on the ground to form a future cut.

The last column in Table 49 under the heading "Others" includes black gum, black locust, birch, chestnut, cucumber magnolia, dogwood, white ash, sycamore, and butternut.

Age of Maturity for Oaks

The proper handling of the preferred species involves a knowledge of the growth peculiarities of each species. For the site on which the study was made white oak and chestnut oak were larger and older than any of the other oaks, and the relationship between total age and diameter breast high was very different. Figures 8 to 12 show the relationship between age at the stump and diameter breast high. Granting that the different species underwent the same competition during their life, white oak and chestnut oak seem to hold a sustained growth rate and a fairly normal relationship between diameter and age. On the other hand the growth rate of red oak, scarlet oak, and black oak seems to be influenced more by competition. For example, 12-inch trees may be as old as the trees 19 and 20 inches in diameter. Under selective cutting it appears that red oak, scarlet oak, and black oak reach tie size and maturity quicker and will show a greater acceleration in growth when the competition of neighboring trees is removed than either chestnut oak or white oak. Although the points on Figures 8 to 12 show a wide dispersion from the average, so wide in fact that no attempt has been made to draw a curve, yet the trend is fairly well shown, and in marking trees for cutting, the forester should keep in mind the behavior of the different species under different degrees of stocking. Competition without doubt has an effect in determining the growth rate, and it seems fairly certain that trees less than 15 inches in diameter at 200 years of age would have reached this size much earlier had they not been shaded. This fact emphasizes the need for removing the poor quality trees from the stand and thereby reducing competition for the good trees that remain. No pretense is made of discussing growth here; these examples are cited to indicate the need of a thorough understanding of the growth relationship in practicing selective cutting in Appalachian hardwoods.

WOODS UTILIZATION

The degree of utilization in the woods depends to a large extent on the kind of product being manufactured. Tie operations afford good opportunities for close utilization along certain lines, such as the reduction of loss due to sweep by cutting short logs.

Fig. 8
Comparison of age and diameter breast high for chestnut oak trees

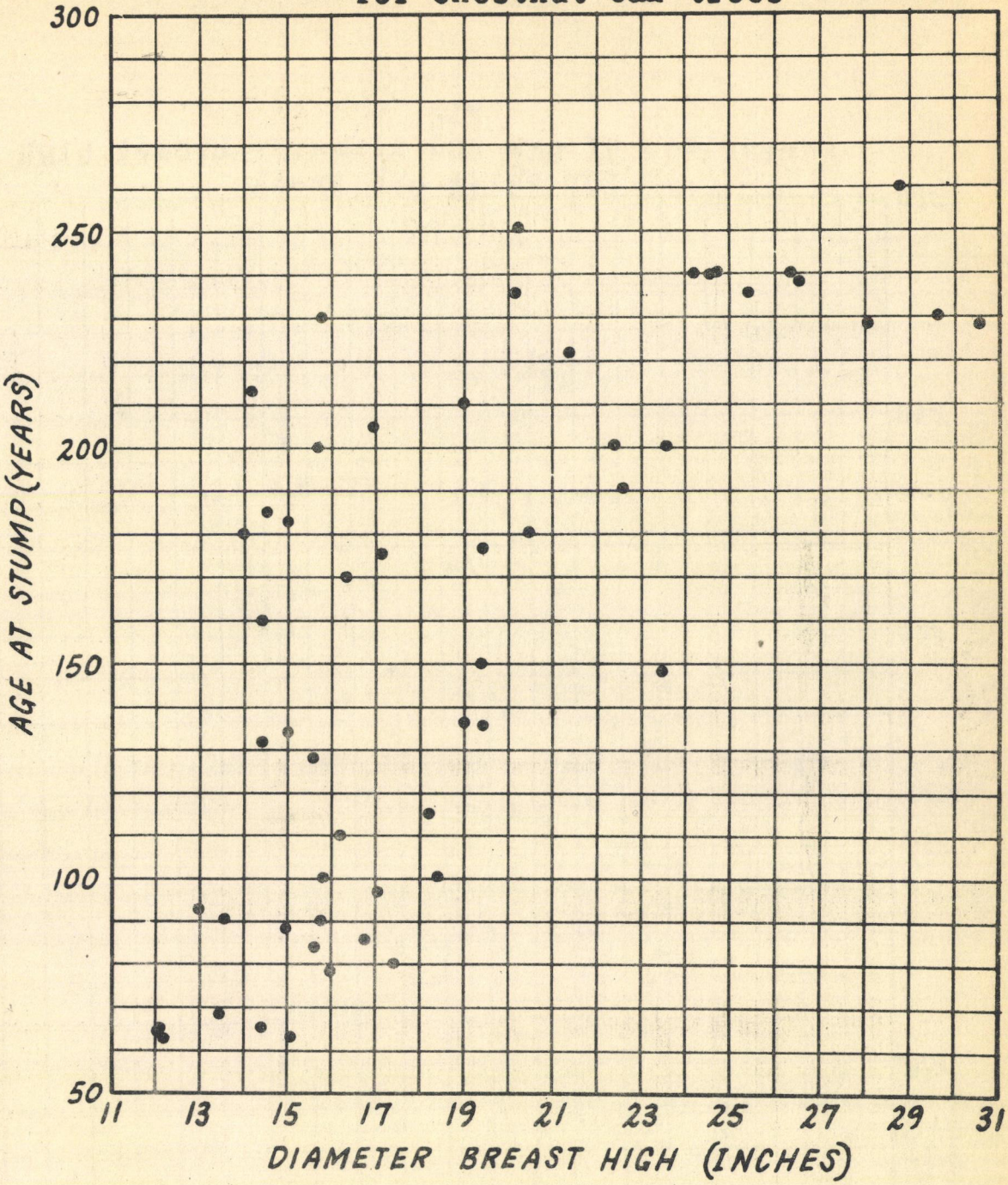


Fig. 9
Comparison of age and diameter breast high for white oak trees

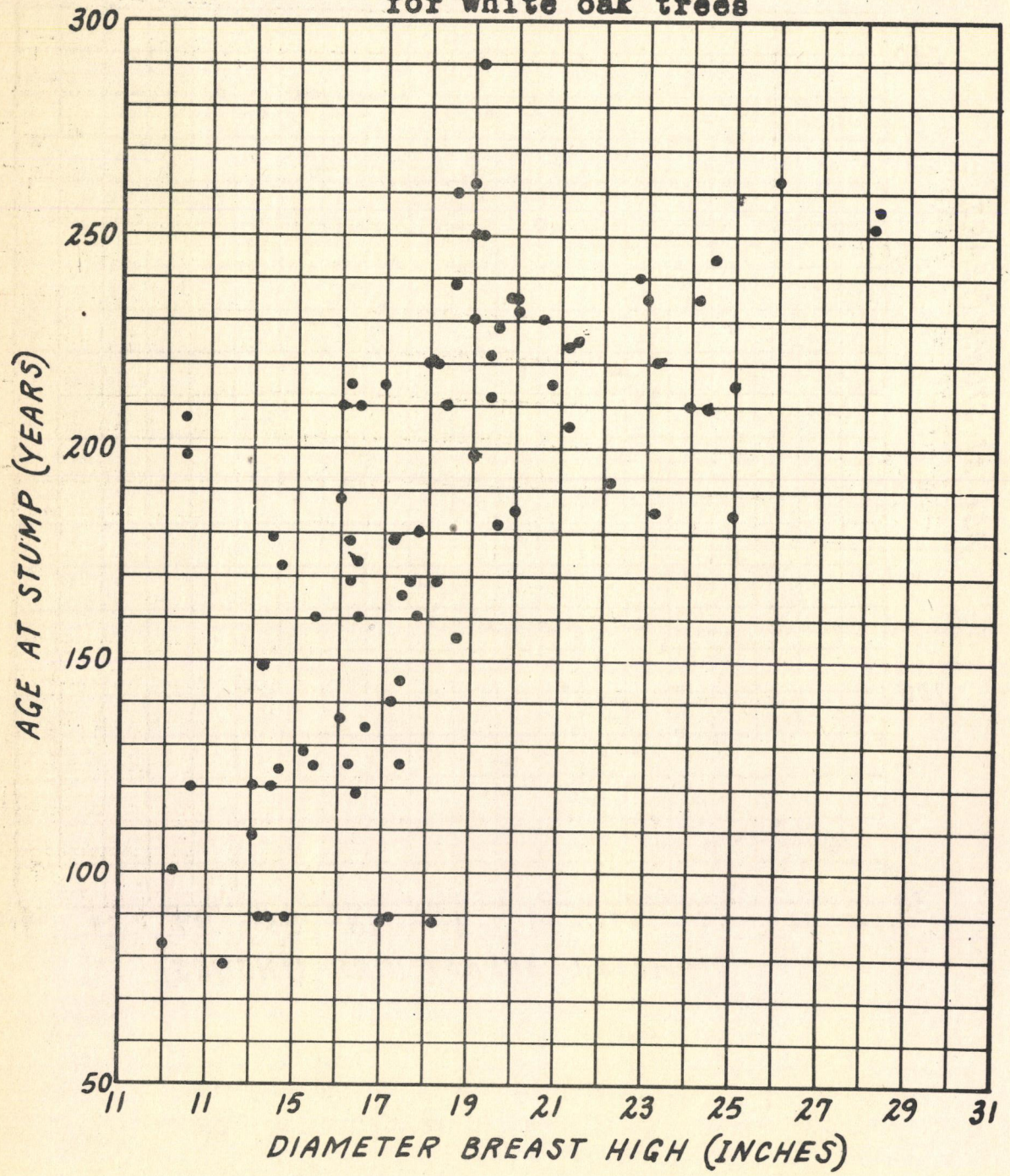


Fig. 10
Comparison of age and diameter breast high for red oak trees

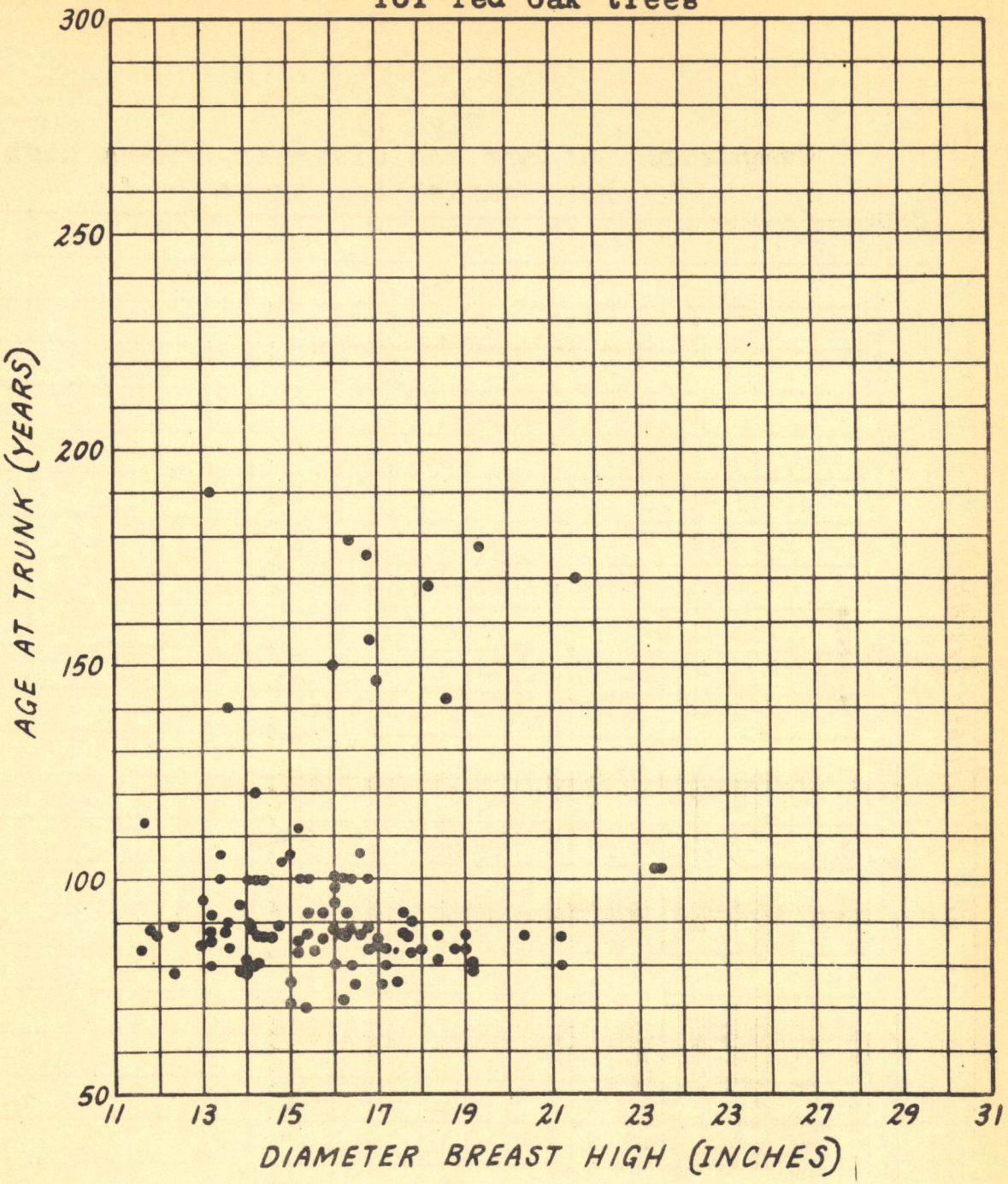


Fig. 11
Comparison of age and diameter breast high
for scarlet oak trees

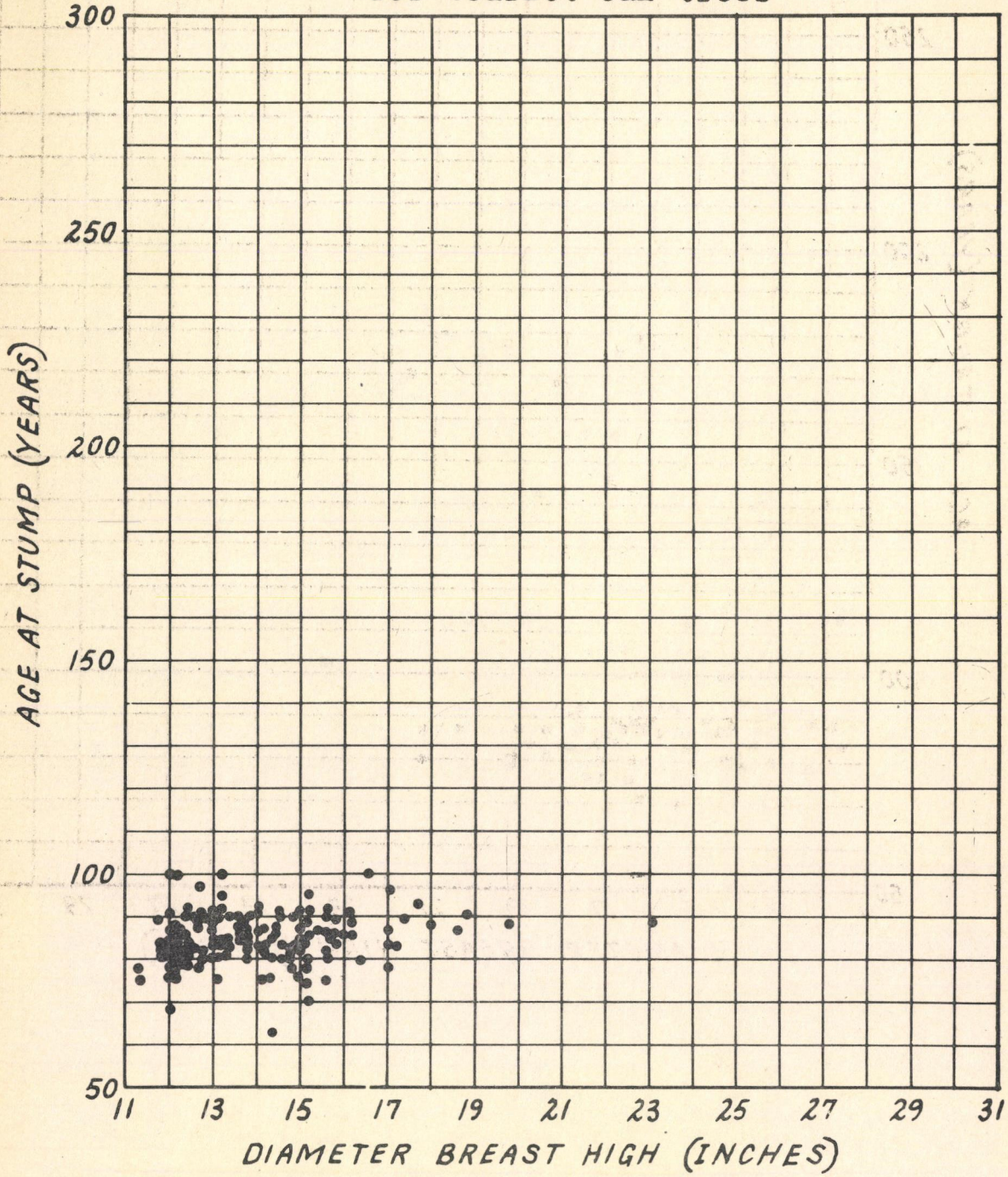
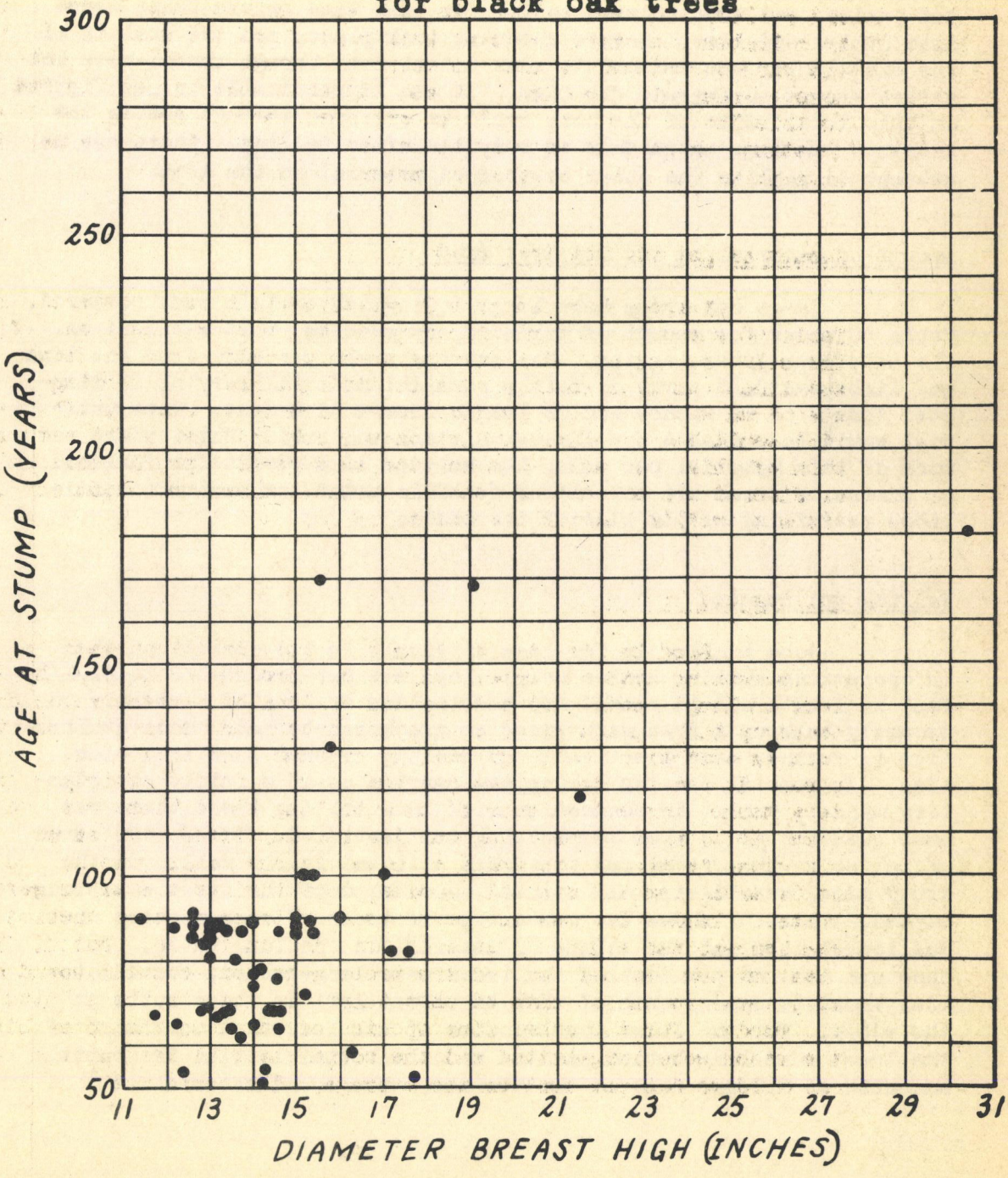


Fig. 12
Comparison of age and diameter breast high for black oak trees



By-Products

The chestnut oak bark was harvested from the study area. In all there were about 15,000 tons on the sale area. Although this activity had no part in the logging and milling study it did have an indirect effect on the operation as a whole. During the peeling season the tie operations were practically shut down. The bark was harvested ahead of the tie operation, and in some instances the same roads served both purposes. The chestnut oak trees were cut down and peeled, and then allowed to lie for some time before being sawed into lumber and ties. Severe checking took place, and the quality of the side lumber was reduced to some extent even though checks were not severe enough to degrade the ties. It was impracticable to get figures on this loss. Some of the loss could be overcome through sawing the chestnut oak logs as quickly as possible after felling. There was no attempt to utilize the other by-product material on the area.

Amount of Material on the Cut-Over Area

Large oak trees have large tops which contain much cordwood. Table 50 shows the amount of cordwood, by species, that was left on the sale area after logging. The average yield per acre from the tops and limbs was 6.15 cords of fairly straight material varying in diameter from 4 to 14 inches and in length from 4 to 8 feet. This material would be suitable for dimension stock and fuel. While there was much of this material per acre, its salvage at a profit for fuelwood or dimension stock did not appear feasible under the economic conditions prevailing at the time of the study.

Felling and Bucking

Good bucking is far less difficult in tie operations than in operations cutting lumber only. Logs are cut from 8-1/2 to 21-1/2 feet in length and in almost any combination of lengths necessary to properly buck up a tree with sweep or crook can be had. Good utilization is further made practicable by cutting crooked logs into slab ties. In general the log making was carried on in a fairly satisfactory manner, except in connection with long butting where there was some question as to when long-butting was justified. Trees were sawed off close to the ground and tops were utilized fairly well. On the study area, considering all species, one-third of the trees were long-butted. Table 51 shows the percentage of trees of each species that was long-butted and the volume of material in the long butts. For chestnut oak, 85 per cent of the trees were long-butted; sound material equal to one-seventh of that taken was left in these butts in the woods. For the other four species of oak less than one-third of the trees were long-butted and the sound material left in the butts amounted to 3.2 per cent on the average. The sound material in

Table 50.--Cordwood left on cut-over areas[1]

Top diameter inside bark	Number of pieces																											
	Oak										Hickory		Yellow poplar		Yellow pine		White pine		Chestnut		Black locust		Red maple		Cucumber		Black gum	
	Chestnut		Red		White		Scarlet		Black																			
Inches	Length		Length		Length		Length		Length		Length		Length		Length		Length		Length		Length		Length		Length		Length	
	4' No.	8' pcs.	4' No.	8' pcs.	4' No.	8' pcs.	4' No.	8' pcs.	4' No.	8' pcs.	4' No.	8' pcs.	4' No.	8' pcs.	4' No.	8' pcs.	4' No.	8' pcs.	4' No.	8' pcs.	4' No.	8' pcs.	4' No.	8' pcs.	4' No.	8' pcs.	4' No.	8' pcs.
4	26	33	16	36	13	11	14	12	4	4	8	11	1	4	8		2	4	4	3	2		2	6		1	2	
5	35	27	15	25	8	11	5	9		2	2	10	3	3	4	2			2	4		6		2	1			1
6	14	27	2	23		8	3	7	2	2	2	9	2	1		1		1		2		3				1		
7	1	16	2	10	1	6	1	4		1		5	2		2			1	1	4		1						
8	8	16		10		8	2	7		2	3	6	1	2		2	1	4		5		1						
9		23	1	7	1		3	1		1		6		2				1		2								
10	3	8	3	5	1	10		4		2	1	3		3		3			1	1								
11	2	6										1				2				1								
12	1	8		1	2	3			1	1	1	3		1														
13	2	1	1																									
14	1	2				2																						
15	1	1			1														1									
16		2	1							1																		
17																												
18											3																	
19																												
20	2				1																							
Total No. Pcs.	96	170	41	117	27	60	28	44	7	16	20	54	9	16	14	10	3	11	9	22	2	11	2	8	1	2	2	1
Cords	10.66		4.80		3.64		1.99		1.07		3.12		.95		.80		.48		1.21		.21		.18		.06		.04	

[1] Actual number of pieces left on 4-3/4 acres (19 circular plots 1/4 acre in area). A total of 29.21 cords of wood or 6.15 cords to the acre was left in the woods (70 cu.ft. to a cord the converting factor).

Table 51.--Percentage of trees butted and material left in woods

Species	Trees butted in: percentage of total number cut	Sound material left in butts in percentage of total net scale taken	Average length of each butt	Average sound volume in each butt
	Per cent	Per cent	Feet	Bd. ft.
Chestnut oak	85	14.6	6.9	25
White oak	32	3.2	6.5	17
Red oak	21	4.3	5.3	25
Scarlet oak	19	2.2	5.3	10
Black oak	17	3.3	7.2	20
Average	31	4.9	6.3	20

the butts was computed by scaling the butt in the same way as the logs were scaled. The net scale, which represented the sound material in the butts, was obtained by deducting from the gross scale a footage sufficient to cover the decayed portion in each long butt. All deductions were made in accordance with the standard instructions for scaling national forest timber. Of the 7,860 board feet of oak butts left in the woods on the study area, 4,585 board feet or 58 per cent were sound material, and under the sale contract would have been classed as merchantable.

Proper butting of mixed hardwoods is difficult. Dominant in the minds of the timber cutters is the fact that they are on a tie and timber job and that logs must be free of rot to cut out first class ties. This fact leads cutters to waste timber in the butts. Much side lumber is lost in large trees if a small area of rot at the stump influences the cutters to butt the tree so the first log is free of rot. The argument in support of this is that lumber does not yield much profit whereas ties do and also that ties are no good if rot is present on the end. It is true that most of the side lumber is narrow and much of it defective, but some butts on this study area were cut too long and some trees were butted that were merchantable under the terms of the sale contract. It is difficult in mixed hardwoods to lay down a fixed rule as to butting. The value of the species, the hauling distance, and the roughness of the topography varied so much that it was impracticable to determine exactly how thick the rim of sound lumber on the end of a rotten log must be before it would pay to take that log to the mill. Large rough butts, in chestnut oak particularly, are hard and costly to handle in small mills and this fact influenced the bucking practice. None of these large butts would make ties, so that their value was based on lumber alone. Theoretically in tie operations it should be possible to cut a defective butt log to a length that would yield one sound tie and some long lumber. For example, a log with rot in the butt is cut 16 feet long on the assumption that the rot runs up only 6 or 7 feet. From the outside of the log much good lumber can be cut; from the inside upper half one good tie can be cut and the lower half containing the rot, of course, is worthless. In actual practice, however, it is difficult to gauge the height of the rot and many logs like the above show rot extending up into the log 9 feet instead of 7 which upsets the plan and makes it necessary to cut the log entirely into lumber or else lumber and one reject tie. Under average conditions a 20-inch chestnut log, if one-half sound, pays its way and yields a slight profit; if only one-third sound, it is on the border line and conditions must be favorable if it is to pay its way. When to long butt is a question that must be decided for each tree independently. The foregoing figures may be used as a guide, but judgment must also be used in setting up long-butting policies for a timber chance. The decision will depend on the product made, the outlets for short lumber, distance to mill, and the like. Some operators bring all logs to the

mill regardless of defect, others have the woods boss cull out the unmerchantable logs, and still others leave the decision as to long-butting up to the log cutters. These varying practices indicate the difficulties surrounding the problem. The study was not sufficiently intensive to set up a definite answer to the question, but the data obtained indicate that the one-third merchantability rule is somewhere near a practicable limit, and in the absence of something better should be used.

Brush Disposal

A good job of top and limb lopping was done on most of the study area. The only reason for lopping and scattering the brush was to reduce the fire hazard. Brush disposal may therefore be considered as a fire protection measure. The cost of brush disposal on the basis of the study figures varied from $0.89 for chestnut oak to $1.28 per thousand board feet, net log scale, for black oak. These figures are higher than is usually thought to be the case. The men who did this work were good workmen and the time actually required to do the work was reasonable; hence, the cost is in line with the actual manual labor required to do the job. Assuming a cut of 20,000,000 board feet on the sale area, the cost of brush disposal will be around $20,000, which raises the question of whether it might not be better business to hire fire guards with some of this money and not bother to lop and scatter the brush. A better plan still would be to utilize the slashings for cordwood and thereby reduce the fire hazard and the cost of brush disposal.

Merchantable Volume Tables

For use in cruising and stumpage appraisal work in tie chances merchantable volume tables for the five species of oak studied are included in this report. (Tables 52 to 56.) They are based on measurements made during the investigation and represent the material taken to the mill under the utilization practices in vogue on the operation.

Sawmill Practice

The characteristics of small sawmills are much the same no matter whether the mills are cutting lumber or ties and timbers or where they are located. They are run intermittently, break down from time to time, have about the same kind of equipment, and the actual operators ordinarily are not rich. The mills on the Shenandoah were no exception. There were, however, some differences in the way the mills were operated, which had less effect on production costs than

Table 52.--Merchantable volume[1] table for chestnut oak

Diameter breast high	Top diameter inside bark	Merchantable length taken	Gross log scale	Mill tally	Ties and timbers	Lumber
Inches	Inches	Feet	Board feet	Board feet	Per cent	Per cent
12	9.4	11	18	25	97.0	3.0
13	9.8	13	29	39	93.0	7.0
14	10.2	15	47	63	89.0	11.0
15	10.5	16	64	83	84.5	15.5
16	10.8	17	82	103	80.5	19.5
17	11.4	18	99	122	76.5	23.5
18	11.9	19	119	142	72.0	28.0
19	12.4	19	140	162	67.5	32.5
20	12.9	20	159	180	63.5	36.5
21	13.4	21	182	200	59.0	41.0
22	14.0	21	205	220	55.5	44.5
23	14.6	22	231	240	51.5	48.5
24	15.1	22	257	260	48.5	51.5
25	15.7	23	286	280	45.5	54.5
26	16.3	23	316	300	43.5	46.5
27	17.0	24	344	320	41.5	58.5
28	17.6	25	378	340	40.0	60.0
29	18.4	25	419	360	38.5	61.5
30	19.1	26	464	380	37.0	63.0
31	19.8	27	512	400	36.0	64.0

[1] Volume actually taken to the mill.

Table 53.--Merchantable volume[1] table for white oak

Diameter breast high	Top diameter inside bark	Merchantable length taken	Gross log scale	Mill tally	Ties and timbers	Lumber
Inches	Inches	Feet	Board feet	Board feet	Per cent	Per cent
11	8.7	14	16	24	100.0	--
12	8.9	16	29	42	94.5	5.5
13	9.2	18	45	62	90.5	9.5
14	9.6	20	61	82	86.0	14.0
15	9.9	22	80	104	81.0	19.0
16	10.3	23	99	124	76.5	23.5
17	10.8	24	118	144	72.0	28.0
18	11.3	26	141	168	67.5	32.5
19	11.8	27	165	192	62.5	37.5
20	12.3	28	195	220	58.0	42.0
21	12.8	29	222	246	53.0	47.0
22	13.4	30	252	272	49.0	51.0
23	14.0	31	283	300	45.0	55.0
24	14.7	32	317	328	40.5	59.5
25	15.3	33	356	360	37.0	63.0
26	16.0	34	392	388	34.0	66.0
27	16.8	34	431	420	31.0	69.0
28	17.4	35	475	456	28.5	71.5
29	18.1	36	523	492	26.0	74.0

[1] Volume actually taken to the mill.

Table 54.--Merchantable volume[1] table for red oak

Diameter breast high	Top diameter inside bark	Merchantable length taken	Gross log scale	Mill tally	Ties and timbers	Lumber
Inches	Inches	Feet	Board feet	Board feet	Per cent	Per cent
11	8.5	20	42	64	100.0	--
12	8.8	22	49	73	93.2	6.8
13	9.0	23	61	88	89.3	10.7
14	9.4	24	76	106	84.4	15.6
15	9.8	26	96	129	79.4	20.6
16	10.2	27	116	151	74.5	25.5
17	10.6	29	142	177	69.4	30.6
18	11.1	30	167	202	64.3	35.7
19	11.7	31	194	225	59.4	40.6
20	12.0	32	226	252	54.4	45.6
21	12.5	33	256	274	49.5	50.5
22	13.0	34	288	297	44.6	55.4
23	13.7	35	320	313	39.6	60.4
24	14.2	36	360	337	34.7	65.3
25	15.0	37	400	356	29.8	70.2
26	15.8	37	452	382	24.9	75.1
27	16.7	38	500	405	20.0	80.0
28	17.4	38	548	417	15.1	84.9
29	18.0	39	600	426	10.2	89.8

[1]Volume actually taken to the mill.

Table 55.--Merchantable volume[1] table for scarlet oak

Diameter breast high	Top diameter inside bark	Merchantable length taken	Gross log scale	Mill tally	Ties and timbers	Lumber
Inches	Inches	Feet	Board feet	Board feet	Per cent	Per cent
11	8.8	19	41	70	97.3	2.7
12	9.2	23	49	79	93.5	6.5
13	9.4	25	59	90	90.5	9.5
14	9.8	27	72	105	86.5	13.5
15	10.2	29	86	126	82.5	17.5
16	10.6	30	99	137	77.5	22.5
17	11.0	32	118	156	72.5	27.5
18	11.3	33	145	176	67.5	32.5
19	11.7	34	170	198	63.0	37.0
20	12.0	35	198	222	58.5	41.5
21	12.4	35	231	250	54.5	45.5
22	12.8	36	368	279	51.0	49.0
23	13.0	36	314	317	47.5	52.5

[1] Volume actually taken to the mill.

Table 56.--Merchantable volume[1] table for black oak

Diameter breast high	Top diameter inside bark	Merchantable length taken	Gross log scale	Mill tally	Ties and timbers	Lumber
Inches	Inches	Feet	Board feet	Board feet	Per cent	Per cent
11	8.2	13	30	54	91.7	8.3
12	8.7	17	42	72	90.5	9.5
13	9.2	21	56	91	88.7	11.3
14	9.7	24	73	112	86.4	13.6
15	10.2	26	92	134	83.7	16.3
16	10.7	27	110	152	80.5	19.5
17	11.2	29	140	185	77.0	23.0
18	11.7	30	160	203	72.3	27.7
19	12.2	31	185	226	67.4	32.6
20	12.7	32	215	254	61.4	38.6
21	13.2	33	245	278	54.8	45.2
22	13.8	34	275	301	49.7	50.3
23	14.3	35	305	323	45.5	54.5
24	14.9	36	350	343	42.3	57.7
25	15.7	36	385	377	40.0	60.0
26	16.1	37	415	388	38.5	61.5

[1]Volume actually taken to the mill.

was expected as will be shown later on. Otherwise, they had many points in common; all used circular inserted-tooth saws, steam power, cut the same kind of timber, specialized in the same products, and were under the general supervision of the same company.

The relation of milling costs on tie operation among the different sized logs is very different from where lumber only is cut. Figure 13 shows the comparative cost of milling red oak logs under the two conditions. In the lumber mill the cost of running the mill was about one-half a cent more per minute than in the tie mill. In the lumber mills the milling cost for small logs was much greater than for large logs. In the tie mills the situation was reversed because the small logs were cut almost entirely into ties, whereas the larger logs were cut into both ties and lumber. For example, in 12-inch red oak trees 94 per cent of the total product was ties and 6 per cent lumber as compared to 26-inch trees in which 16 per cent of the product was ties and 84 per cent lumber. This fact, plus the inability of small mills to handle large logs efficiently accounts for the upward trend of the cost curve in the large diameters.

No attempt was made at any of the mills to salvage the excess edgings and slabs except at Mill 7 where about one-third of the slabs were sold for fire wood. The possibilities for a closer utilization of this material were not obvious.

Ties were normally cut from 1/8 to 1/4-inch in excess of the required cross-sectional dimensions and lengths were usually from 1 to 2 inches over the nominal length. The lumber was edged on the headsaw except at Mill 5 where it was put through an edger. On the whole the lumber was not so well manufactured as was actually done in the small mills studied in North Carolina. Considerable skill, however, was exercised by the sawyers in getting the largest possible tie or ties out of a log. A form of taper sawing was usually practiced in sawing parallel to the bark on two sides of the log. Mill 8 was particularly good in taking the taper out of a log from the heart, if it were rotten, instead of from the sound outside of the log.

The average output per thousand board feet, mill tally, per ten-hour day, considering the same delay time of 27.6 per cent at all mills, for Mill 5 was 11,100 board feet per day; Mill 7, 6,620 board feet; and Mill 8, 8,940 board feet. Mill 5, as previously noted, was a larger mill, more or less permanently installed, roofed, and equipped with edger, cut-off saw, and log turner in addition to a headsaw. The equipment at Mills 7 and 8 consisted of a headsaw only. Mill 7 represented a cheap, temporary, roofless, more or less careless set-up. It was not well maintained, and breakdowns were frequent. Mill 8 was roofed, set on substantial foundations, and well maintained. First glance might lead one to believe that Mill 5 would be the most efficient and cheapest per thousand board feet to operate and that Mill 7 would be the poorest mill. A comparison of the operating efficiency

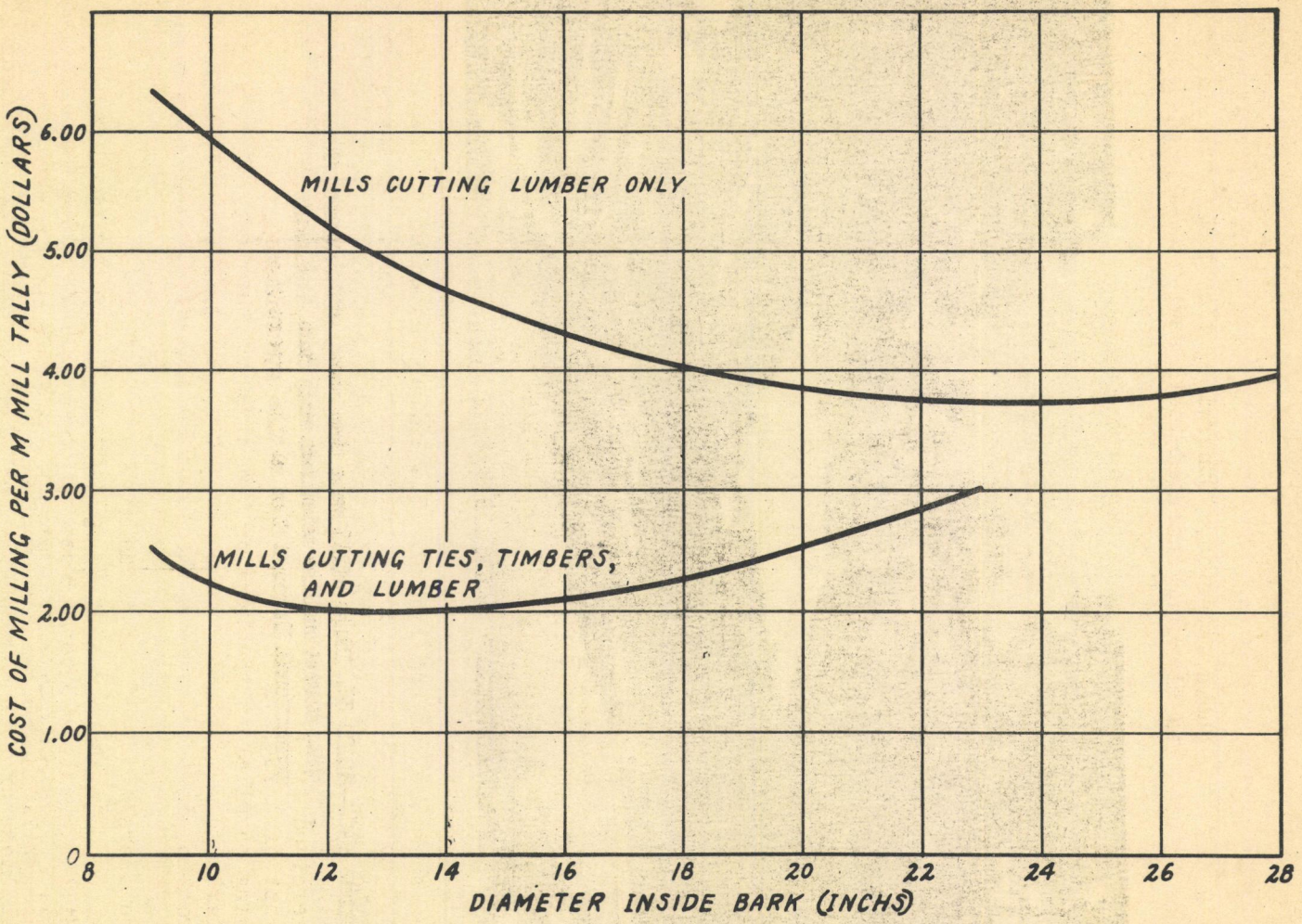


FIG. 13

COST OF MILLING PER M BOARD FEET MILL TALLY FOR RED OAK LOGS ON TIE AND LUMBER OPERATIONS

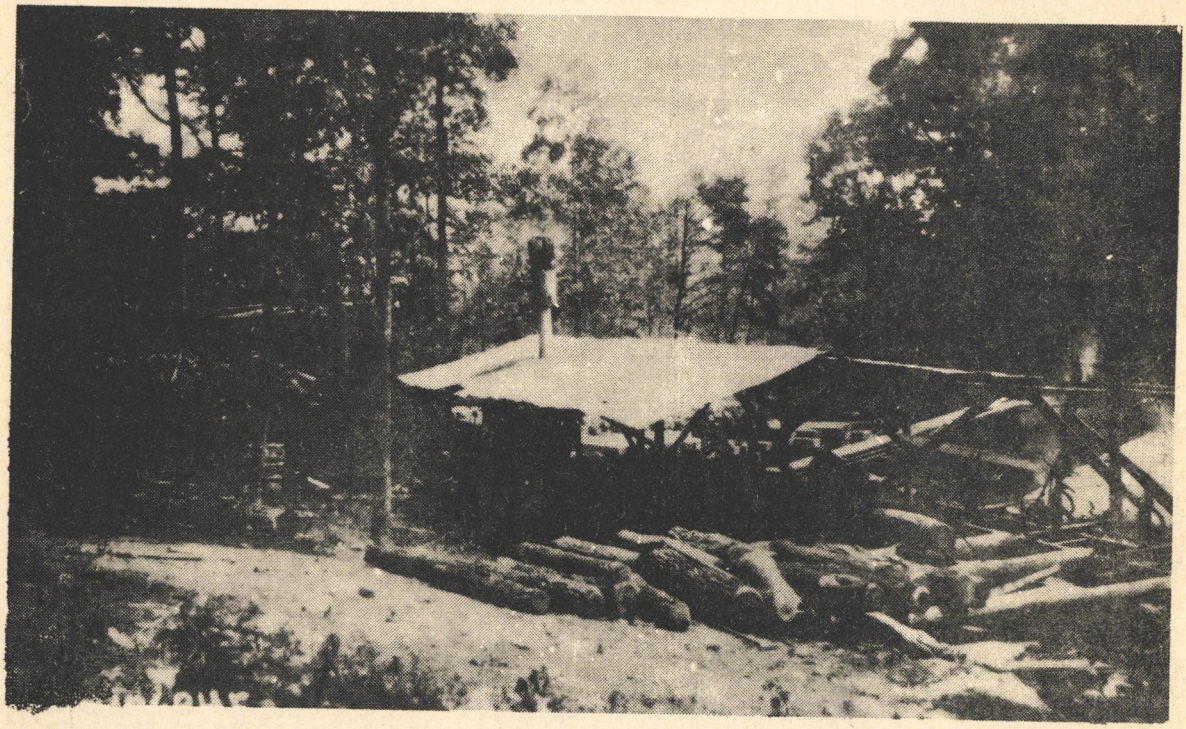


Figure 14.--Mill 8. This mill was the most efficient of the three mills studied and had the most practical layout for a tie operation.

of these mills was made for the purpose of determining the kind of a mill best suited to tie operations. Table 57 shows the comparative cost per thousand board feet, mill tally, of producing ties, timbers, and lumber at the three mills described. It was rather surprising to find that the difference in the production cost per thousand board feet cut among the mills was slight, the maximum difference being 25 cents or about 10 per cent. This comparison obtains only, however, if the same delay time is used in each case. On this basis Mill 7 cut logs the cheapest, and Mill 5 had the highest cost. Actually, however, the delay time at both Mills 5 and 7 was greater than 50 per cent, so great in fact that it was considered too abnormal for use in the results of the study. Actually the costs at Mills 5 and 7 for this reason would be higher than at Mill 8. At Mill 5 the delay was due principally to a lack of logs. At Mill 7 the delays were due to breakdowns, lack of steam, poor planning, and a general inability to get things moving. Part of this delay was due to the men running the mill, and part was due to the fact that the mill was hastily set up, the equipment was not under a roof, and there was no opportunity to keep a supply of partly seasoned, reasonably dry wood. Manufacturing costs at Mill 5 were high because its installation was costly, and it was so large that the company seemingly was unable to keep it supplied with logs after the timber close by had been cut out. Considering all things Mill 8 seemed to represent the kind of a mill best suited to tie production. Its installation was a little more costly than Mill 7, but the extra expense for good foundations, a roof, and good maintenance was fully justified by the increased output and efficiency of operation. (Fig. 14.)

Edging on the headsaw is not ordinarily considered good practice, but in tie operations where only part of the log is cut into lumber such a practice has a place, particularly where the lumber is sold to a flooring plant where further manufacture is done. From a utilization standpoint such a practice was fully justified in the operation studied because the lumber was sold at a price in conformity with its utility value to a subsidiary company. Furthermore, by placing the boards on the carriage carefully the edging was accomplished without undue waste. Of course, the lumber was somewhat waney and needed trimming in many cases, but this made little difference in its utilization in the flooring plant where it was completely reworked. On the other hand, if the value of the lumber was determined strictly on its grade and not on its utility value then the small sawmill operator would have to edge and trim carefully and installation of an edger and cut-off saw would be necessary.

OUTPUT TABLES

Tables 58 to 60 give the costs per day for felling and bucking, skidding, and milling.

Table 57.--Comparison of cost of operating Mills 5, 7, and 8 on the Shenandoah National Forest

Mill No.	Mill crew	Wages per day	Cost per mill min.	Mill min. per M mill tally	Cost per thousand board feet mill tally	
					Excluding delay time	Including delay time[1]
5	Sawyer	$ 6.25				
	Tail sawyer	3.50				
	Edgerman	3.50				
	Trimmerman	3.00				
	Fireman	3.00				
	2 off-bearers	6.00				
	Waterboy	1.00				
	Total and av.	26.25	$0.0437	39.17	$ 1.71	$ 2.36
7	Sawyer	5.00				
	Tail sawyer	3.00				
	Off-bearer	3.00				
	Fireman	3.00				
	Total and av.	14.00	0.0233	65.69	1.53	2.11
8	Sawyer	5.75				
	Deckman	3.00				
	Tail sawyer	3.00				
	2 off-bearers	6.00				
	Fireman	3.00				
	Total and av.	20.75	0.0346	48.72	1.68	2.32

[1] The delay time at Mill 8 was 27.6 per cent -- a figure used in calculating milling costs for the three mills.

Table 58.--Time required to fell and buck mixed oak trees, and the quantity produced, gross log scale, per man in a ten-hour day

Diameter breast high	Felling and bucking time per man per M gross log scale	Quantity produced by one man in a 10-hour day, gross log scale
Inches	Man-minutes	Board feet
12	757	793
13	726	827
14	709	846
15	680	883
16	654	918
17	629	954
18	600	1000
19	581	1033
20	562	1068
21	543	1105
22	528	1136
23	520	1153
24	497	1207
25	484	1240
26	463	1296
27	448	1340
28	428	1400
29	410	1463
30	392	1530
31	369	1627

Table 59.--Skidding - output of logs, gross log scale, per team per ten-hour day by distances[1]

Skidding distance	Quantity that can be skidded in 10 hours by one team gross log scale	Capacity of average trail gross log scale
Feet	Board feet	Board feet
100	6585	109
200	5218	110
300	4210	112
400	3555	113
500	3070	115
600	2765	117
700	2510	118
800	2305	120
900	2140	121
1000	2005	123
1100	1882	125
1200	1780	127
1300	1696	128
1400	1620	130
1500	1560	132
1600	1502	134
1700	1452	135
1800	1398	137
1900	1357	139
2000	1320	141
2100	1278	143
2200	1250	144
2300	1220	146
2400	1187	148
2500	1165	150
2600	1143	152
2700	1117	154
2800	1097	156
2900	1080	158
3000	1060	160
3500	993	170
4000	932	179

[1]The service of a swamper or grabdriver was necessary for each two teams. Surface varied from smooth bottom land to rough rocky steep hill sides. The number of logs averaged about twenty to a thousand board feet.

Table 60.--Output of ties, timbers, and lumber, mill tally, per ten-hour day by diameter classes for mixed oak logs at Mill 8

(Six men were required to operate the mill)

Diameter breast high	Milling time per thousand board feet: mill tally[1]	Production per 10-hour day	
		Net log scale:	Mill tally
Inches	Minutes	Board feet	Board feet
8	66	3430	9090
9	72	4166	8353
10	64	5515	9375
11	61	6305	9836
12	60	6944	10000
13	61	7340	9836
14	63	7559	9524
15	63	7937	9524
16	64	8082	9375
17	63	8282	9524
18	63	8282	9524
19	64	8223	9375
20	66	8044	9090
21	68	7878	8824
22	71	7613	8451
23	74	7438	8108
24	78	7188	7691
25	80	7075	7500
26	82	7104	7317

[1] Includes 27.6 per cent delay time due to breakdowns, filing saws, and the like.